

JPRS 77870

20 April 1981

# USSR Report

PHYSICS AND MATHEMATICS

No. 67



FOREIGN BROADCAST INFORMATION SERVICE

#### NOTE

JPRS publications contain information primarily from foreign newspapers, periodicals and books, but also from news agency transmissions and broadcasts. Materials from foreign-language sources are translated; those from English-language sources are transcribed or reprinted, with the original phrasing and other characteristics retained.

Headlines, editorial reports, and material enclosed in brackets [ ] are supplied by JPRS. Processing indicators such as [Text] or [Excerpt] in the first line of each item, or following the last line of a brief, indicate how the original information was processed. Where no processing indicator is given, the information was summarized or extracted.

Unfamiliar names rendered phonetically or transliterated are enclosed in parentheses. Words or names preceded by a question mark and enclosed in parentheses were not clear in the original but have been supplied as appropriate in context. Other unattributed parenthetical notes within the body of an item originate with the source. Times within items are as given by source.

The contents of this publication in no way represent the policies, views or attitudes of the U.S. Government.

#### PROCUREMENT OF PUBLICATIONS

JPRS publications may be ordered from the National Technical Information Service (NTIS), Springfield, Virginia 22161. In ordering, it is recommended that the JPRS number, title, date and author, if applicable, of publication be cited.

Current JPRS publications are announced in Government Reports Announcements issued semimonthly by the NTIS, and are listed in the Monthly Catalog of U.S. Government Publications issued by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Indexes to this report (by keyword, author, personal names, title and series) are available through Bell & Howell, Old Mansfield Road, Wooster, Ohio, 44691.

Correspondence pertaining to matters other than procurement may be addressed to Joint Publications Research Service, 1000 North Glebe Road, Arlington, Virginia 22201.

Soviet books and journal articles displaying a copyright notice are reproduced and sold by NTIS with permission of the copyright agency of the Soviet Union. Permission for further reproduction must be obtained from copyright owner.

<b>REPORT DOCUMENTATION PAGE</b>		<b>1. REPORT NO.</b> JPRS 77870	<b>2. Recipient's Accession No.</b>
<b>4. Title and Subtitle</b> USSR REPORT: PHYSICS AND MATHEMATICS, No. 67		<b>5. Report Date</b> 20 April 1981	
<b>7. Author(s)</b>		<b>6. Performing Organization Rept. No.</b>	
<b>9. Performing Organization Name and Address</b> Joint Publications Research Service 1000 North Glebe Road Arlington, Virginia 22201		<b>10. Project/Task/Work Unit No.</b>	
<b>12. Sponsoring Organization Name and Address</b>  As above		<b>11. Contract(G) or Grant(G) No.</b> (C) (G)	
<b>13. Type of Report &amp; Period Covered</b>		<b>14.</b>	
<b>15. Supplementary Notes</b>			
<b>16. Abstract (Limit 200 words)</b>  The report contains articles, abstracts and news items on aerohydrodynamics, magnetohydrodynamics, physics of crystals and semiconductors, molecular, atomic and plasma physics, optics, spectroscopy, physical measurements, and on theoretical and applied mathematics.			
<b>17. Document Analysis a. Descriptors</b>  USSR Acoustics Optics Lasers Nuclear Physics Structural Mechanics Plasma Physics Mathematics  <b>b. Identifiers/Open-Ended Terms</b>  <b>c. COSATI Field/Group</b> 12A, 20A, 20E, 20F, 20H, 20I, 20K, 20M			
<b>18. Availability Statement</b> Unlimited Availability Sold by NTIS Springfield, Virginia 22161		<b>19. Security Class (This Report)</b> UNCLASSIFIED	<b>21. No. of Pages</b> 63
		<b>20. Security Class (This Page)</b> UNCLASSIFIED	<b>22. Price</b>

USSR REPORT  
PHYSICS AND MATHEMATICS

No. 67

CONTENTS

ACOUSTICS

Scattering of Sound by the Ocean Floor in Shallow-Water Regions (Survey).....	1
Analysis of a Re-Radiated Signal From an Elastic Sphere Exposed to a Directional Spherical Wave.....	2
Unsteady Sound Field From an Empty Hollow Elastic Sphere.....	2

CRYSTALS AND SEMICONDUCTORS

Formation of Intermetallic Compounds in the Niobium-Iron System Under the Action of a Shock Wave Produced by Laser Irradiation....	4
Effect of Explosion Plasma on Ferrocenone Alloys.....	5
On the Nature of Acoustoelectric Instability in a Germanium Strain-Gate Diode.....	6

ELECTRICITY AND MAGNETISM

Accounting for the Influence of Channels Beneath the Slots in Calculating the Parameters for the Massive Rotor of an Induction Turbine Generator.....	7
Creepage Dischargers for Currents of ~50 kA With High Firing Frequency.....	8

FLUID DYNAMICS

Theory of Aerodynamic Sound Self-Excitation: Amplification of Surface Waves.....	9
Nonspherical Collapse of a Cavitation Bubble Between Two Solid Walls.....	10

A Pulsating Submerged Jet and Generation of Thermally Induced Oscillations.....	10
Emission of Strong Shock Waves in Normal-Density Helium.....	11
Experimental Study of the Relation Between Heat Exchange and Friction Drag in a Turbulent Boundary Layer With Longitudinal Pressure Gradient.....	12
Heat Exchange of a Continuous Moving Plate With an Ambient Medium.....	12
Rate of Propagation of a Filtration Combustion Wave in a Gaseous Oxidant With Inert Gas Additive.....	13
Aerodynamic Characteristics of a Circular Cylinder in a Transverse Flow.....	14
Aerodynamic Forces on a Rotating Smooth Cylinder in a Transverse Flow.....	15

#### LASERS AND MASERS

Calculation of Dynamic Parameters of Supersonic Flow of Laser Mixture $\text{CO}_2:\text{N}_2:\text{He}$ .....	16
Gas Breakdown by $\text{CO}_2$ Laser Emission Near a Metal Surface in the Absence of Well Developed Vaporization.....	17
Calculating the Interaction of Laser Radiation With an Aluminum Vessel and its Vapor.....	17
Investigation of the Current-Voltage Characteristic of a Gas-Discharge Laser.....	18
Influence That Mirror Vibrations Have on the Stability of Beat Frequencies of a Ring Laser.....	19
Determining the Coefficients of Absorption of Helium-Xenon Laser Emission in Hydrocarbons and Hydrogen Sulfide.....	19
Influence That Noise Perturbations Have on the Mode of Beats With the Resonator Frequency in a Ring Laser.....	20
Quasi-CW Mode of a Helium-Cadmium Laser With RF Pumping.....	21
Stimulated Emission of a Steady-State Ultrashort Pulse Train in Traveling Wave Ring Lasers.....	21

Attenuation of Competition of Opposed Waves in Stimulated Emission of Harmonics in a Solid-State Ring Laser.....	22
A CO <sub>2</sub> Pulse Laser With Pre-Ionization by UV Emission From Capillary-Arc Discharges.....	23
Feasibility of a Low-Temperature Gamma Laser.....	23
Stimulation of Emission With Wavelength of 4.3 $\mu\text{m}$ in a TE CO <sub>2</sub> Laser.....	24
Gas Lasers With Incoherent Optical Pumping.....	25
Lasers Emitting on a Wavelength of 16 $\mu\text{m}$ .....	26
Experimental Investigation of the Curvature of the Middle Phase Front of a Laser Beam in a Turbulent Atmosphere.....	26
MAGNETOHYDRODYNAMICS	
Nature of a Helical MHD Dynamo Instability.....	28
The Law of Conservation of Energy and Uniqueness of Classical Solutions of Nonlinear MHD Problems.....	29
NUCLEAR PHYSICS	
Theoretical Study of the Hydrodynamics of Spherical Targets With Consideration of the Refraction of Laser Radiation.....	30
On the Mechanism of Generation of Hot Electrons in a Laser Plasma...	31
Radial Distribution of the Concentration of Oxygen Nuclei in the Plasma of the Tokamak-10.....	31
On Using Conversion of Laser Radiation to Fast Electrons in the Problem of Laser Fusion.....	32
Estimation of the Parameters of a 120-cm Cyclotron With Conversion to AVF Operation.....	33
OPTICS AND SPECTROSCOPY	
Nonlinear Defocusing of a Focused Beam: Thin Ray From the Focus....	34
Optical Discharges.....	34
Doppler-Free Nonlinear Processes in Strong Optical Fields.....	35

## PLASMA PHYSICS

Dipole Resonance of an Elliptical Plasma Cylinder in a Dielectric Shell.....	37
Interference-Holographic Investigation of a Supersonic Plasma Jet of Pulsed Discharge.....	38
Determining Magnetic Field Strength in a Hydrogen Plasma From Resonant Faraday Rotation of the Plane of Light Polarization.....	38
Some Peculiarities of a Gas-Discharge Ion Source.....	39
Investigation of the Dynamics of Plasma Production and Formation of a Compression Region in a Gaseous Magnetoplasma Compressor.....	40
Development of Langmuir Oscillations With Transverse Motion of Plasma in a Magnetic Field.....	41
Concerning the Skin Effect in Relativistic and Pulsed Plasma Accelerators.....	42
Violation of Thermodynamic Equilibrium in Electric-Arc Plasma Sources.....	43
Investigation of the Nonequilibrium Properties of an Arc-Discharge Plasma in a Mixture of $N_2-CO_2-He$ by the Method of Laser Probing...	43
Spectral Properties of a Dense (Nonideal) Air Plasma.....	44
A Scientific Engineering Approach to the Problem of Modeling and Analyzing the Dynamics of the Plasmotron as a Technological Facility. II. Method of Determining the Static Characteristics of the Process in the Plasmotron.....	45

## STRESS, STRAIN AND DEFORMATION

Absorption of Ultrasound by Metals During Their Plastic Deformation.....	46
Temperature-Time Dependence of the Radiation Strength of Transparent Solids.....	47
Optimization Problem of Dynamic Interaction of a Laminar Orthogonal Plate With an Acoustic Shock Wave.....	47

## SUPERCONDUCTIVITY

Contactless Superconducting Excitation Systems for High Power Turbine Generators.....	49
---	----

The Ginzburg-Landau Equation for a Two-Component Fermi Liquid.	
2. Equation for Superconducting Proton Current.....	50

#### THERMODYNAMICS

A Study of the Cooling Rate of the Components of the End Regions of High Power Turbine Generators.....	51
A Study of the Heating of a TGV-300 Generator in Induction Operation Without Excitation.....	52
Optimizing the Thermal Status of the Components of the End Zone of Large Turbine Generators Operating in Flexible Load Modes.....	53
Stochastic Conditions of Thermochemical Heterogeneous Processes That Take Place in a Field of Laser Radiation.....	54
Investigation of the Commutation Properties of Electrically Exploded Foils in Arc-Quenching Media. I.....	54

#### MATHEMATICS

Limits of Solutions and Complexity of Systems of Convex Diophantine Inequalities.....	56
Group Pursuit of Several Evaders by a Single Pursuer.....	57
Simple Pursuit and Evasion on a Compact.....	58
An Efficient Method of Solving Differential Games With Many Pursuers.....	58



UDC 534.87:551.463.26:534

SCATTERING OF SOUND BY THE OCEAN FLOOR IN SHALLOW-WATER REGIONS (SURVEY)

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 26, No 5, Sep-Oct 80 pp 641-654  
manuscript received 25 Jan 80

BUNCHUK, A. V., Institute of Acoustics imeni N. N. Andreyev, USSR Academy of Sciences, and ZHITKOVSKIY, Yu. Yu., Institute of Oceanology imeni P. P. Shirshov, USSR Academy of Sciences

[Abstract] All physical and specifically the acoustic characteristics of the ocean floor can be referred to the porosity and density of the ocean floor. Both the acoustic velocity and the damping coefficient are functions of the floor porosity, the former smoothly dipping to a minimum at a 75% porosity and the latter sharply peaking to a maximum at a 55% porosity. The energy characteristics of sound scattering, namely its power and intensity, have been determined experimentally by various methods which fall into two categories: tone-pulse measurements with a directional transmitter-receiver antenna and detonation measurements with a large explosive charge serving as a powerful wideband sound source. Backscattering by silt, clay, and sand beds was measured by these methods in shallow-water shelf regions and the results reveal that, while it depends on the grazing angle over the 5-90° range and sharply peaks within 50-80°, it remains independent of the frequency within the 2-100 kHz range. Side scattering by shallow-water shelves was also measured and the results were analyzed with consideration of roughness anisotropy of the bottom surface along with lens inhomogeneities in the floor. The overall conclusion is that scattering by the ocean floor is different in shallow-water and deep-water regions. Figures 9; tables 1; references 38: 19 Russian, 19 Western.  
[35-2415]

## ANALYSIS OF A RE-RADIATED SIGNAL FROM AN ELASTIC SPHERE EXPOSED TO A DIRECTIONAL SPHERICAL WAVE

Kiev MATEMATICHESKIYE METODY I FIZIKO-MEKHANICHESKIYE POLYA in Russian No 11, 1980 pp 47-51 manuscript received 2 Nov 78

PODSTRIGACH, Ya. S., PODDUBNYAK, A. P. and POROKHOVSKIY, V. V., Institute of Applied Problems of Mechanics and Mathematics, UkSSR Academy of Sciences

[Abstract] The problem of scattering of a spherical wave in water was studied by Hickling [see R. Hickling, "Analysis of Echoes from a Solid Elastic Sphere in Water", JOURNAL OF THE ACOUSTIC SOCIETY OF AMERICA, Vol 34, No 10, 1962 pp 1582-1592], and it was shown that a source of acoustic energy emits in a solid angle of  $4\pi$ . In this paper the authors analyze numerical calculations of the amplitude and directional response of a steady-state echo signal from a steel sphere in water exposed to acoustic energy from a transducer with energy concentrated in the far field in a limited solid angle of less than  $4\pi$ . It is assumed that the acoustic axis of the conical beam passes through the origin of the spherical system of coordinates at the center of the emitter. The pressure in the wave reflected from the sphere is determined, and it is shown that the mechanism of excitation of given contributions of surface waves to the overall echo signal can be controlled by means of the spatial response of the incident waves. The results are compared with calculations for the limiting cases of acoustically hard and acoustically soft spheres. Figures 4, references 8: 6 Russian, 2 Western. [54-6610]

## UNSTEADY SOUND FIELD FROM AN EMPTY HOLLOW ELASTIC SPHERE

Kiev MATEMATICHESKIYE METODY I FIZIKO-MATEMATICHESKIYE POLYA in Russian No 11, 1980 pp 51-56 manuscript received 27 Sep 78

GRILITSKIY, D. V. and ONISHCHUK, V. Ya., L'vov University

[Abstract] The authors consider the problem of analyzing the field radiated from a spherical object exposed to a sharply directional probing pulse, and in particular in the case where a concentrated time-variable force is applied to the surface of an elastic sphere. A solution is found for the problem of determining the steady acoustic field from a hollow empty elastic sphere immersed in

an infinite ideal compressible liquid when a concentrated force is applied in a pulse of finite duration to the outside of the sphere at a given point. It is shown that the flexural mode makes the greatest contribution to the field radiated by a given point of a thin empty elastic sphere in the case of low frequencies. This contribution decreases with increasing thickness or stiffness of the shell. Figures 4, references 3: 2 Russian, 1 Western.  
[54-6610]

FORMATION OF INTERMETALLIC COMPOUNDS IN THE NIOBIUM-IRON SYSTEM UNDER THE ACTION OF A SHOCK WAVE PRODUCED BY LASER IRRADIATION

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian  
Vol 33, No 2, 20 Jan 81 manuscript received 16 Dec 80

DEKHTYAR, I. Ya., IVANOV, L. I., KARLOV, N. V., NIKIFOROV, Yu. N.,  
ISHCHENKO, M. M., PROKHOROV, A. M. and YANUSHKEVICH, V. A., Physics Institute  
imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] Pulsed laser radiation can appreciably change the properties of an irradiated specimen by forming point defects. Diffusion of such defects to the surface, and nonequilibrium properties can alter the chemical activity of the surface, producing nonequilibrium chemical processes in the surface layer. In this paper the authors report the first observation of the formation of intermetallic compounds as shock waves produced by laser exposure pass through a specimen. The studies were done on the niobium-iron system. A niobium foil was clad with an iron layer and exposed to laser emission on the unclad surface. The pressure on the resultant shock wave front was calculated at  $3.3 \cdot 10^4$  kgf/cm<sup>2</sup>. The thickness of the foil eliminated the possibility of any thermal effect from laser exposure on the iron cladding. The formation of intermetallic compounds was confirmed by Mossbauer spectroscopy. This is an example of solid-state laser chemistry. Figures 2, references 7 Russian.  
[66-6610]

## EFFECT OF EXPLOSION PLASMA ON FERROCARBON ALLOYS

Novosibirsk FIZIKA GORENIYA I VZRYVA in Russian Vol 16, No 4, Jul-Aug 80  
pp 142-149 manuscript received 5 Apr 79

POPOVA, N. V., FEDOROVA, I. P. and PUPOV, Ye. G., Dnepropetrovsk

[Abstract] The authors studied changes in the microstructure of ferrocabon alloys exposed to the action of an explosion plasma. The products resulting from detonation of an explosive charge were sent to a special cylindrical chamber, compressing and heating nitrogen, argon or air. The velocity of the shock wave in the gas was measured by oscilloscope, using ionization sensors. Another sensor near the specimen was used to determine the duration of plasma action. A piezoelectric sensor was used for measuring pressure in the chamber. A total of 19 simple and doped alloys were studied with carbon content of 0.04-5% and various concentrations of manganese, silicon, sulfur, phosphorus, chromium, nickel, copper, titanium, molybdenum and cerium. The specimens were made in the form of flat plates cemented together. The microstructure was studied by etching. Microhardness was also measured. It was found that the explosion plasma produces considerable changes in the microstructure and also hardens the surface layer of ferrocabon alloys. Upon exposure to a nitrogen-containing plasma, the hardness in the surface layer increases to  $2 \cdot 10^3$  kg/mm<sup>2</sup>. In low-carbon steels, twinning of ferrite may take place even at low pressures of  $10^9$  N/m<sup>2</sup> if the loading duration is long enough. Figures 2, references 14: 13 Russian, 1 Western.  
[59-6610]

UDC 537.311.33

## ON THE NATURE OF ACOUSTOELECTRIC INSTABILITY IN A GERMANIUM STRAIN-GAGE DIODE

Yerevan UCHENYYE ZAPISKI YEREVANSKOGO GOSUDARSTVENNOGO UNIVERSITETA:  
YESTESTVENNYE NAUKI in Russian No 2, 1980 pp 82-87 manuscript received 24 Dec. 79

MINASYAN, M. V., Department of Physics of Semiconductors and Dielectrics,  
Yerevan State University

[Abstract] In previous research, the author used thermodynamic methods to derive expressions for the mechanical (acoustic) impedance of a strain-sensitive point-contact diode, where elastic properties in the vicinity of the contact are supplemented by thermoelastic stresses from heating. Generation of acoustic and electrical waveforms on a point contact with germanium has been observed with connection in either direction. To verify the possible thermoacoustic nature

of this effect, conditions of gradual suppression of the first (coherent with mechanical oscillation) harmonic of electric power across the diode are established and experimentally realized. The measurement data reveal a correlation between this process and the amplitudes of onset of self-oscillations that shows up as a reduction of these self-oscillations, and in the limit as disappearance of the effect. The suppressed regenerating mechanism in the given experiments is found to be predominant in the effect. Figures 4, references 6: 4 Russian, 2 Western.  
[62-6610]

UDC 621.313.322.001

## ACCOUNTING FOR THE INFLUENCE OF CHANNELS BENEATH THE SLOTS IN CALCULATING THE PARAMETERS FOR THE MASSIVE ROTOR OF AN INDUCTION TURBINE GENERATOR

Kiev PROBLEMY POVYSHENIYA NADESHNOSTI MOSHCNYKH TURBOGENERATOROV in Russian  
1979 signed to press 26 Jul 79 pp 103-106

AS'KOVSKIY, Yu. N., OSTAPCHUK, L. B. and KHOPERSKIY, S. V., Kiev

[Abstract] The eddy currents produced by slip in an induction turbine generator with rotor excitation in turn generate heating with necessitates the cooling of the massive rotor drum, since a considerable temperature gradient can appear between the rotor surface and its yoke. A radical technique for eliminating these losses is the milling of channels under the slots in the region of the base of a rotor slot, through which a coolant is passed in an axial direction. These subslot channels change the nature of the electromagnetic field and the parameters of the rotor, and they must be considered in the redesign. A simple model is proposed for the massive rotor with subslot channels. The solution of the resulting problem for the layered model is based on Maxwell's equations which are used to define the input characteristic impedance of the model as  $E_1/H_1$ , where  $E_1$  and  $H_1$  are the electrical and magnetic field intensities at the surface of the model (the rotor). The simultaneous solution of the resulting differential equations for the layers of the model generates an expression for the input impedance of a three layered model; the expression can be used to compute the parameters of a rotor and the simplified case of a two layer model with the appropriate correction factor is also analyzed. A sample calculation is given for an induction generator with a total capacity of 235 MVA, a rotor diameter of 1,175 mm, 48 rotor slots, slot dimensions of 30.6 x 179 mm, subslot channel dimensions of 10 x 30 mm. Figures 1; references: 3 Russian.  
[12-8225]

## CREEPAGE DISCHARGERS FOR CURRENTS OF 50 kA WITH HIGH FIRING FREQUENCY

Yerevan UCHENYYE ZAPISKI YEREVANSKOGO GOSUDARSTVENNOGO UNIVERSITETA:

YEESTESTVENNYE NAUKI in Russian No 2, 1980 pp 78-81 manuscript received 20 Sep 79

AKOPOV, R. A., ANTABLYAN, O. G., GRIGORYAN, A. V. and KHANIKYANTS, Ye. K.,  
NII PKS [expansion not given], Yerevan State University

[Abstract] Simple air-gap dischargers are proposed to handle currents of 5-50 kA by creepage over glass. These dischargers are used in 0.5 MeV electron accelerators with beam current of 10-30 kA. Silicate, aluminosilicate and pyrex glasses are used. These materials have very high tracking resistance and wear resistance. Permittivity ranges from 4 to 8 at frequencies of 1 MHz, which improves conditions for creepage. The working recurrence rate reaches 100 Hz. Delay between the beginning of the igniting pulse and the instant when the discharge current reaches 10% of maximum for a strip discharger at an operating frequency of 50 Hz is  $40 \pm 10$  ns. Their low inductive reactance and resistance makes the proposed dischargers suitable for use in the primary circuits of high-current electron accelerators with a high firing frequency. Figures 2, references 4 Russian.

[62-6610]



THEORY OF AERODYNAMIC SOUND SELF-EXCITATION: AMPLIFICATION OF SURFACE WAVES

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 26, No 5, Sep-Oct pp 655-662  
manuscript received 20 Dec 78 after correction 13 Jul 79

ANDRONOV, A. A. and FABRIKANT, A. L., Institute of Applied Physics, USSR Academy of Sciences

[Abstract] Aerodynamic generation of a whistle is best explained by the mechanism of positive feedback, through negative friction, in a self-excitation system. Here this effect is evaluated in terms of interaction between a gas stream and surface acoustic waves. A stream of a nonhomogeneous nonviscous gas with a plane-parallel quiescent velocity profile is considered, then an examination is made of small pressure perturbations in this stream which cause its stratification. The reflection coefficient for these perturbations is calculated, assuming first a uniform flow within each segment of the now discontinuous velocity profile, which yields the dispersion equation for waves at a shearing surface in a stream. This equation in turn yields the instability increment, when the reflection coefficient is a complex quantity and a resonance layer exists in the stream. Then the frequency-dependent imaginary part of the reflection coefficient depends on the curvature of the velocity profile: the stream amplifies synchronous surface waves where its velocity profile is convex and attenuates synchronous surface waves where its velocity profile is concave. It is not possible to make the entire stream amplify surface waves, unless such waves are excited by the stream within a finite volume such as that of a Helmholtz resonator with a polychromatic space spectrum of vibrations. Figures 2; references 15: 7 Russian, 8 Western.  
[35-2415]

## NONSPHERICAL COLLAPSE OF A CAVITATION BUBBLE BETWEEN TWO SOLID WALLS

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 26, No 5, Sep-Oct 80 pp 695-699  
manuscript received 11 Jun 79 after correction 1 Feb 80

DESHKUNOV, N. V., KUVSHINOV, V. I., KUVSHINOV, G. I. and PROKHORENKO, P. P.,  
Physico-Technical Institute and Institute of Physics, BSSR Academy of Sciences

[Abstract] The collapse of a cavitation bubble at distances from its center comparable with its initial radius is analyzed, such a situation arising in processes like ultrasonic surface treatment. An initially spherical bubble is considered between two parallel solid walls and the equation of its surface at any later time is determined in a spherical system of coordinates. The ambient fluid is assumed to be incompressible and nonviscous, initially stationary, with the pressure inside the bubble always lower than at infinity but also increasing adiabatically as the bubble volume decreases. Effects of surface tension and gravity are disregarded. Calculations are based on the Laplace equation for the velocity potential and its solution in the form of Legendre polynomials. The shape of the bubble surface is found to depend on the ratio of initial bubble radius to distance between walls, and almost not to depend on the pressure ratio. The presence of a second solid wall lengthens the collapse time and causes formation of an annular jet splitting the bubble into equal halves. This reduces erosion. The authors thank S. I. Voytovich for performing the calculations on a computer. Figures 3; tables 1; references 5: 4 Russian, 1 Western.

[35-2415]

## A PULSATING SUBMERGED JET AND GENERATION OF THERMALLY INDUCED OSCILLATIONS

Minsk INZHENERNO-FIZICHESKIY ZHURNAL in Russian Vol 40, No 1, Jan 81 pp 5-11  
manuscript received 11 Dec 79

POPOV, O. M. and SERGEYEV, S. I.

[Abstract] The flow properties of a viscous fluid flowing periodically from the submerged opening of a pipe into a large reservoir and again sucked into the pipe were investigated as a method of generating thermally induced oscillations in irregularly heated channels of industrial equipment and also in devices for intensification of heat and mass transfer. The oscillating submerged jet essentially had an identical shape of a slightly spreading hyperboloid or a jet in both forward and reverse flow at low Reynolds numbers. The velocity profiles

of the forward and reverse jet were close to the calculated profiles. The rod analogy was violated only slightly. The rod analogy was clearly violated when Reynolds number was increased and stable flow occurred at Reynolds numbers of 20 to 40. The liquid flow rate attenuated sharply a short distance beyond the vortex generated upon expulsion from the pipe in the form of a jet. The volume occupied by the vortex increased with a further increase of Reynolds number of 60-120 and the vortex boundaries became washed out and deformed on the axis of the jet, contributing to breakup of the vortex and separation of it from the mouth of the pipe. As Reynolds numbers increased from 170 to 420, motion with several mixed vortices was observed. The dimensions of the vortices increased, interacted with each other and penetrated the steady circulation flow as Reynolds numbers were increased from 420 to more than 620. The thermally induced oscillations due to intensification of heat transfer are applicable to controlled delivery of heat to cryogenic apparatus for generation of a purging gas in it. Figures 3; references 7: 6 Russian, 1 Western.  
[44-6521]

UDC 535.23:533.6

#### EMISSION OF STRONG SHOCK WAVES IN NORMAL-DENSITY HELIUM

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 34, No 1, Jan 81 pp 76-81  
manuscript received 26 Feb 80

BOGOYAVLENSKAYA, Ye. G., NENCHINOV, I. V. and SHUVALOV, V. V.

[Abstract] Numerical methods are used to solve the unsteady radiation-gasdynamics problem of propagation of a shock wave produced by movement of a flat piston at velocities of 50-70 km/s in normal-density helium. Detailed tables of the optical and thermodynamic properties of helium were used. The spectral composition of radiation was accounted for by introducing 500 spectral intervals. The method of averaged transport equations was used to reduce the volume of calculations. The paper gives the spectral characteristics of shock wave radiation in helium, and the feasibility of using such waves as emitters is discussed. A comparison is made with estimates by the Zel'dovich-Razer theory, and with the numerical calculations for air. The calculations given in the paper can be used to study the radiative properties of strong shock waves in the ultraviolet region, where they have not yet been determined experimentally. The theoretical predictions could be confirmed by experiments with present-day shock wave generators that use the energy of explosives and the shaped-charge effect, such as the Voytenko compressor. Figures 4, references 8 Russian.  
[67-6610]

## EXPERIMENTAL STUDY OF THE RELATION BETWEEN HEAT EXCHANGE AND FRICTION DRAG IN A TURBULENT BOUNDARY LAYER WITH LONGITUDINAL PRESSURE GRADIENT

Moscow TEPILOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 18, No 6, Nov-Dec 80  
pp 1196-1202 manuscript received 15 Nov 79

REPIK, Ye. U. and KUZENKOV, V. K., Moscow

[Abstract] The paper gives the results of an experimental study of the relation between heat transfer and surface friction in a turbulent boundary layer when there is a longitudinal pressure gradient in the flow produced by a specially shaped insert installed in the wall of the wind tunnel. The experimental data are used to calculate the values of the coefficient of the Reynolds analogy:

$$s = \frac{2St}{c_f},$$

where  $St = \frac{q_w}{\rho_{\infty} u_{\infty} c_p (T_{\infty} - T_w)}$  is the local value of the dimensionless heat transfer

coefficient,  $c_f = \frac{\tau_w}{\rho_{\infty} u_{\infty}^2 / 2}$  is the local coefficient of friction drag,  $q_w$  is the heat flux density at the wall,  $\tau_w$  is the tangential stress at the wall,  $T_w$  is wall temperature,  $u_{\infty}$ ,  $\rho_{\infty}$ ,  $T_{\infty}$  are the velocity, density and temperature respectively of the gas on the outer surface of the boundary layer. The local values of  $St$  and  $c_f$  were determined from the initial slopes of temperature and density profiles in the boundary layer in the immediate vicinity of the wall. The authors give the temperature and velocity profiles in a turbulent boundary layer as measured over a wide range of negative and positive pressure gradients. Figures 7, references 10: 7 Russian, 3 Western.  
[32-6610]

## HEAT EXCHANGE OF A CONTINUOUS MOVING PLATE WITH AN AMBIENT MEDIUM

Moscow TEPILOFIZIKA VYSOKIKH TEMPERATUR in Russian Vol 18, No 6, Nov-Dec 80  
pp 1203-1210 manuscript received 1 Oct 79

DORFMAN, A. Sh. and NOVIKOV, V. G., Institute of Technical Thermal Physics, USSR Academy of Sciences

[Abstract] An investigation is made of principles that govern heat exchange between a continuous moving flat plate and a moving or stationary medium assuming an arbitrary law of temperature behavior of the plate surface. Flow in the

boundary layer is laminar, and the thermophysical properties of the medium are independent of temperature. Energy dissipation is disregarded. An exact solution is found for the equations of the laminar boundary layer. An investigation is made of the influence that an external flow has on heat exchange on the plate as it emerges from a draw plate, assuming that the ambient medium moves in the same direction, but with a different constant speed. Figures 8, references 12: 5 Russian, 7 Western.

[32-6610]

UDC 536.46

RATE OF PROPAGATION OF A FILTRATION COMBUSTION WAVE IN A GASEOUS OXIDANT WITH INERT GAS ADDITIVE

Novosibirsk FIZIKA GORENIYA I VZRYVA in Russian Vol 16, No 4, Jul-Aug 80 pp 37-44  
manuscript received 30 Jul 79

LEBEDEV, A. D. and SOKOLOV, A. S., Leningrad

[Abstract] Recently there has been an upsurge of interest in theoretical analysis of processes of combustion of pressed powders in a gaseous oxidant. Previous research has dealt with the influence of thermophysical and filtration characteristics on the structure and velocity of a combustion wavefront in an unbounded porous medium, and with the effect of an inert gas component on combustion behavior. In this paper the authors study the way that the rate of propagation of a flame front depends on parameters of a porous medium in a gaseous oxidant with inert additive. The burning porous material is taken as infinite in extent, and the pressure is assumed to be high, which is a necessary condition for a self-sustaining reaction. Approximate analytical expressions are derived for the rate of propagation of the combustion wave. Comparison with exact computer calculations shows satisfactory agreement. References 3 Russian.

[59-6610]

## AERODYNAMIC CHARACTERISTICS OF A CIRCULAR CYLINDER IN A TRANSVERSE FLOW

Novosibirsk IZVESTIYA SIBIRSKOGO OTDELENIYA AKADEMII NAUK SSSR: SERIYA  
TEKHNIЧЕСКИХ НАУК in Russian No 8(323), Issue 2, Jun 80 pp 114-124 manuscript  
received 9 Jul 79

BYCHKOV, N. M. and KOVALENKO, V. M., Institute of Theoretical and Applied  
Mechanics, Siberian Department, USSR Academy of Sciences, Novosibirsk

[Abstract] An experimental study is made of aerodynamic forces, pressure distribution and pressure pulsations on a circular cylinder in a transverse flow. The experiments were done in a low-turbulence subsonic ITPM T-324 wind tunnel at Reynolds numbers from  $10^5$  to  $6 \cdot 10^5$  on a specially developed facility enabling registration of instantaneous forces and pressures with fairly high accuracy and quick response. The measurements were made under four sets of conditions differing in the degree of flow turbulence and roughness of the surface of the cylinder. In the case of transverse low-turbulence flow around a smooth cylinder in the critical region of Reynolds numbers, a considerable sign-alternating lift  $Y$  is observed with coefficient that varies from  $C_y = -0.85$  to  $C_y = +0.85$ . The drag  $X$  also shows quite appreciable fluctuations under these conditions, so that  $C_x$  lies between 0.45 and 0.75. In other modes, the fluctuations of forces  $Y$  and  $X$  are much less than those indicated. This is an indication of asymmetry and unsteadiness of the position of points of separation of the boundary layer, which is confirmed by measurements of pressure and pressure pulsations around the cylinder. The pressure pulsations on the surface of the cylinder increase beginning with the forward critical point, and reach maximum values in the pre-separation zone, especially under conditions that are critical with respect to Reynolds numbers for all four sets of conditions studied. Turbulization of the incident flow or an increase in roughness of the cylinder stabilizes the position of points of separation, ensuring more symmetric flow around the cylinder. This is accompanied by a reduction in the critical Reynolds number, and also a reduction in pulsations of pressure, lift and drag in the zone of critical Reynolds numbers. In addition, turbulization reduces the minimum drag of a smooth cylinder in the critical zone. Figures 13, references 11: 4 Russian, 7 Western.  
[63-6610]



## AERODYNAMIC FORCES ON A ROTATING SMOOTH CYLINDER IN A TRANSVERSE FLOW

Novosibirsk IZVESTIYA SIBIRSKOGO OTDELENIYA AKADEMII NAUK SSSR: SERIYA  
TEKHNICHESKIKH NAUK in Russian No 8(323), Issue 2, Jun 80 pp 125-135

manuscript received 9 Jul 79

BYCHKOV, N. M. and KOVALENKO, V. M., Institute of Theoretical and Applied  
Mechanics, Siberian Department, USSR Academy of Sciences, Novosibirsk

[Abstract] An experimental investigation is made of transverse flow around a rotating cylinder, which has a decisive influence on aerodynamic characteristics for all angles of attack except for the region of unseparated flow, i. e. at  $\alpha \rightarrow 0$ . The experiments were done in the ITPM T-324 low-turbulence subsonic wind tunnel at Reynolds numbers from  $10^5$  to  $6 \cdot 10^5$  and two degrees of turbulence:  $\epsilon = 0.04\%$  and  $\epsilon = 0.7\%$ . The rotation parameters ranged from  $\theta = 0$  to  $\theta = 1$ , where  $\theta$  is the ratio of the peripheral rotational velocity to the velocity of the incident flow. A special facility enabled measurement of instantaneous forces with high precision. In the low-turbulence flow, abrupt changes in lift were observed with a magnitude comparable to the drag. This effect is a result of a rapid change in position of asymmetric points of separation of the boundary layer. Hysteresis of aerodynamic forces was observed in the region of abrupt change. It is shown that in the critical region of Reynolds numbers rotation stabilizes flow around a cylinder and reduces fluctuations of aerodynamic forces. The lift reaches a value of  $-0.85$  as  $\theta \rightarrow 0$ . Turbulization of the flow smooths out the change in aerodynamic forces by stabilizing the position of points of flow separation. Figures 13, references 6: 3 Russian, 3 Western.  
[63-6610]

CALCULATION OF DYNAMIC PARAMETERS OF SUPERSONIC FLOW OF LASER MIXTURE  
 $\text{CO}_2:\text{N}_2:\text{He}$

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 254, No 4, 1980 pp 867-869  
 manuscript received 5 Jun 80

BASOV, N. G., academician, GLOTOV, Ye. P., DANILYCHEV, V. A., KOTEROV, V. N.  
 and SOROKA, A. M., Physics Institute imeni P. N. Lebedev, USSR Academy of  
 Sciences

[Abstract] The flow of gas mixture in a continuous supersonic electroionization  $\text{CO}_2$  laser with a constant Mach number along the flow and a constant maximum specific laser output power, is examined. Keeping the Mach number constant prevents shock waves that detract from the optical and electrical characteristics of the reactor. Maximum power is maintained because specific relaxation losses in the reactor decrease as the optical flux density increases. Only certain discharge channel profiles and electron beam current densities permit operation in the examined mode. An equation is given for the specific mass energy output as the main parameter that determines the efficiency of an open cycle laser. The specific mass energy output and efficiency are plotted as functions of the reactor intake pressure. The reactor intake temperature is the lowest temperature at which  $\text{CO}_2$  does not condense in the mixture. The energy output increases with the initial pressure, but efficiency decreases due to an increase of relaxation losses. The maximum specific energy output and corresponding initial pressure are plotted as functions of the Mach number. The optimum pressure increases sharply with the Mach number. Stable spontaneous discharge requires a highly homogeneous electric field intensity along the flow, which conflicts with the requirement of a constant Mach number. The technical problems impeding the development of a continuous open cycle supersonic electroionization  $\text{CO}_2$  laser are surmountable. Figures 1; references 5: 3 Russian, 2 Western. [7-7872]



GAS BREAKDOWN BY CO<sub>2</sub> LASER EMISSION NEAR A METAL SURFACE IN THE ABSENCE OF WELL DEVELOPED VAPORIZATION

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 51, No 1, Jan 81 pp 73-77  
manuscript received 12 Feb 80

KOVALEV, A. S. and POPOV, A. M., Scientific Research Institute of Nuclear Physics attached to Moscow State University imeni M. V. Lomonosov

[Abstract] The possible mechanisms of low-threshold optical breakdown of gases in the absence of developed surface vaporization were investigated. A series of equations is derived to describe the time of breakdown of the air and vapor mixture by the laser emission. It is shown that the initial degree of ionization of air and the initial absorptivity of laser radiation are principally dependent on the metal vapor in the air. A criterion of breakdown is found that defines the minimum surface temperature at which gas breakdown can occur:

$$k_1 N_0 - \nu_d > 0,$$

where  $k_1$  is the rate constant of ionization of atoms by electron impact,  $N_0$  is the equilibrium concentration of metal vapor over the surface, and  $\nu_d$  is diffusion frequency. This condition ensures non-zero electron concentration near the surface. References 9: 6 Russian, 3 Western.  
[46-6521]

## CALCULATING THE INTERACTION OF LASER RADIATION WITH AN ALUMINUM VESSEL AND ITS VAPOR

Moscow ZHURNAL VYCHISLITEL'NOY MATEMATIKI I MATEMATICHESKOY FIZIKI in Russian Vol 20, No 6, Nov-Dec 80 pp 1513-1524 manuscript received 28 Jan 80

ZUBOV, V. I., KRIVTSOV, V. M., NAUMOVA, I. N. and SHMYGLEVSKIY, Yu. D., Moscow

[Abstract] A numerical solution is found for the unsteady axisymmetric problem of the effect of laser radiation on an aluminum vessel and on its vapor. The vessel has a flat bottom of given radius, and is conical in shape with a known angle of taper and length of side wall, and with given wall thickness. The wall temperature is a given constant value at time zero. Laser emission with given frequency and intensity is normally incident on the bottom of the vessel. The analyzed process includes heating and vaporization of the bottom of the vessel,

motion and heating of the vapor, self-radiation of the vaporized mass, heating and vaporization of the side wall. An example is given with laser quanta of 1.16 and 7.29 eV. The work required four years to complete, and the calculation nearly exhausts the technical capabilities of the BESM-6 computer. The problem was suggested by I. V. Nemchinov, who assisted the authors on all stages of the solution. Figures 6, references 12 Russian.  
[29-6610]

UDC 621.378.3

#### INVESTIGATION OF THE CURRENT-VOLTAGE CHARACTERISTIC OF A GAS-DISCHARGE LASER

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 33, No 4, Oct 80 pp 634-638  
manuscript received 3 Dec 79

GRYAZNEVICH, V. P. and PRIVALOV, V. Ye.

[Abstract] A theoretical analysis is made of the falling section of the current-voltage response curve of the active element of a helium-neon cold-cathode laser. Discharge was investigated in helium, neon and a mixture of the two at pressures of 2-6 mm Hg and currents of 0.5-8 mA. The slope of the curve on the falling section ranged from 150 to 15 V/mA. An approximate expression is derived for this section with consideration of only multistage ionization. The approximation is qualitatively confirmed by experimental data for a laser tube 1.1 mm in diameter and 150 mm long. The analysis will not fit the experimental results if only direct ionization is considered. Apparently, excited atoms play a considerable part in the mechanism of formation of the falling section of the current-voltage curve. The authors thank L. D. Tsendin for assistance. Figures 2, references 13: 8 Russian, 5 Western.  
[53-6610]

# INFLUENCE THAT MIRROR VIBRATIONS HAVE ON THE STABILITY OF BEAT FREQUENCIES OF A RING LASER

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 33, No 4, Oct 80  
pp 639-642 manuscript received 17 Jan 80

KUTSAK, A. A., KRUGLIK, G. S., KUZNETSOV, G. M. and ZUYKOV, I. Ye.

[Abstract] In the published literature on the frequency response of a ring laser, the effect of beat frequency instability due to fluctuations of the cavity perimeter has been attributed chiefly to the position of the lasing frequency on the amplification line, and accordingly to the difference in indices of refraction for opposed waves. However, this situation occurs only for slow motions of the mirrors such as those resulting from thermal expansion. External factors may cause the mirrors of a ring laser to vibrate at frequencies of the order of tens of Hz or more. Calculations by the authors show that in this case the Doppler effect must be considered on the moving mirrors, since it also leads to instability of the measured beat frequency. Natural frequencies of the cavity of a ring laser are calculated for the case of vibrating mirrors in the approximation  $V/c \ll 1$ , where  $V$  is mirror velocity, and  $c$  is the speed of light. The Doppler effect leads to a difference frequency between opposed waves that causes errors in measurements of angular displacements of the laser. Figure 1, references 6 Russian.  
(53-6610)

# DETERMINING THE COEFFICIENTS OF ABSORPTION OF HELIUM-XENON LASER EMISSION IN HYDROCARBONS AND HYDROGEN SULFIDE

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 33, No 4, Oct 80  
pp 742-744 manuscript received 10 Dec 79

MIRONOV, V. D., POPOV, A. I. and SADCHIKHIN, A. V.

[Abstract] Laser absorption gas analysis can be used to determine trace amounts of pollutants in the atmosphere. The helium-xenon laser is a good candidate for use in detecting hydrocarbons and hydrogen sulfide, since a number of its transitions with intense and stable stimulated emission lie in the range of 3-4  $\mu\text{m}$ , covering the range of absorption lines of hydrocarbons and hydrogen sulfide. This paper gives the results of measurement of the coefficient of absorption  $\epsilon$  on transitions  $\lambda_1 = 3.3676 \mu\text{m}$ ,  $\lambda_2 = 3.5080 \mu\text{m}$  and  $\lambda_3 = 3.6859 \mu\text{m}$  for methane, ethane, propane, n-butane, isobutane, and on transition  $\lambda_3$  for hydrogen sulfide.

It is found that radiation with  $\lambda_1$  is strongly absorbed in ethane, propane and butanes, and can be used for quantitative analysis of these hydrocarbons. Radiation on the other wavelengths is weakly absorbed or nearly unabsorbed in hydrocarbons, and can be used as comparison signals in doing two-wave measurements. Emission with  $\lambda_2$  is absorbed so weakly in hydrogen sulfide that it would not be feasible to use it for detection. References 9: 3 Russian, 6 Western.  
[53-6610]

UDC 621.378.3

INFLUENCE THAT NOISE PERTURBATIONS HAVE ON THE MODE OF BEATS WITH THE RESONATOR FREQUENCY IN A RING LASER

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 34, No 1, Jan 81 pp 82-88  
manuscript received 8 Jun 79

KRUGLIK, G. S. and FEDCHENYA, I. I.

[Abstract] Previous research has proved the existence of a beat mode with frequency coinciding with the difference of resonator frequencies in a ring laser. Such a mode arises under the influence of spontaneous emission in the lasing channel, and is asymptotically stable under certain conditions. The mode is also stable with respect to continuously acting perturbations. Thus the beat frequency is practically constant for low enough fluctuation parameters of the system. On the other hand, at a sufficiently high noise level, noise properties will determine the solution of the equations of motion for the phase difference of opposed waves and observability of the interference pattern of the beats. In this paper the authors estimate the threshold level of fluctuations as a function of internal parameters of a ring laser and the power of technical fluctuations of these parameters, and derive a formula for the correlation function of small deviations from the mode of stable beats at the resonator frequency. Expressions are also given for the asymptotic average variances of these deviations. The authors thank N. A. Usova for doing computer calculations. Figures 2, references 7 Russian.  
[67-6610]

## QUASI-CW MODE OF A HELIUM-CADMIUM LASER WITH RF PUMPING

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 34, No 1, Jan 81 pp 89-92  
manuscript received 11 Jun 79

KOROL'KOV, A. N. and RUDELEV, S. A.

[Abstract] An investigation is made of conditions of excitation of a helium-cadmium mixture in a transverse radio-frequency discharge stimulated by an oscillator operating in the 1.5-5 MHz band. The discharge was periodically interrupted by square pulses with recurrence rate of 300 Hz-8 kHz. The duration of current pulses was from 16  $\mu$ s to 1 ms. The average power of the oscillator was about 150 W for a pulse duty factor of 0.5. Laser radiation was sent to the input of a DMR-4 monochromator, spontaneous emission was coupled out through a hole in one of the electrodes on the side of the discharge tube to the input of a DFS-12 spectrometer. A photomultiplier was used for reception of the spontaneous emission and pulsed lasing. The IM0-2 power meter was used for recording the average lasing power. The signals from the photomultiplier was the current pulse from the coupling loop were sent to the inputs of a two-beam oscilloscope. It was found that quasi-cw pumping increases the average lasing power as the rf current pulse recurrence rate is increased with a simultaneous reduction in duration. The optimum duty factor for pulses longer than 200  $\mu$ s is 0.5, corresponding to the maximum average power. The  $\text{He}^+ \rightarrow \text{Cd}$  charge transfer cross section is about  $10^{-15}$  cm<sup>2</sup>. Figures 3, references 5 Russian. [67-6610]

UDC 621.378.5

## STIMULATED EMISSION OF A STEADY-STATE ULTRASHORT PULSE TRAIN IN TRAVELING WAVE RING LASERS

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 34, No 1, Jan 81  
pp 173-176 manuscript received 6 Mar 80

KOTOMTSEVA, L. A. and SAMSON, A. M.

[Abstract] The paper gives the conditions of stimulated emission of steady-state ultrashort radiation pulses in a train with a recurrence period close to the time required for passage of emission around the cavity of a ring laser. These conditions are derived by analyzing a system of differential-difference equations for electric field amplitude, polarization and gain of an active medium with uniform broadening for a traveling-wave ring laser. The results of the analysis are illustrated by examples of numerical modeling of processes

of stimulated emission of such pulses in solid-state, gas and dye lasers. Numerical solution of the proposed system of equations is much simpler than solution of the partial differential equations that have been proposed by other authors. The results are in agreement with data found by more complicated techniques. Computer simulation shows that self-pulsing should be feasible in traveling wave ring lasers with different active media. The optimum parameters of such systems can be calculated from the formulas proposed in this paper. Figures 2, references 5: 4 Russian, 1 Western.  
[67-6610]

UDC 621.378.325

#### ATTENUATION OF COMPETITION OF OPPOSED WAVES IN STIMULATED EMISSION OF HARMONICS IN A SOLID-STATE RING LASER

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 255, No 2, 1980 pp 339-341  
manuscript received 16 Jul 80

DOTSENKO, A. V., KORNIYENKO, L. S., KRAVTSOV, N. V., LARIONTSEV, Ye. G. and SHELAYEV, A. N., Scientific Research Institute of Nuclear Physics, Moscow State University imeni M. V. Lomonosov

[Abstract] Strong competitive interaction of opposed waves is typical of solid-state ring lasers with uniformly broadened luminescence line. This interaction leads either to self-modulated lasing modes characterized by periodic transfer of energy from one wave to another, or to suppression of one of the waves. Stimulated emission of harmonics within the cavity introduces intensity-dependent losses for the opposed waves on the fundamental frequency, these losses being lower for the less intense wave, which should prevent competitive suppression of one of the waves. In this paper the authors investigate the properties of solid-state ring lasers with intracavity lasing of the second harmonic. It is theoretically shown that such a lasing mode gives stable beat-frequency emission with approximately equal intensities of opposed waves, the equalizing of intensities becoming more effective with increasing difference between the natural frequencies of the cavity. It is also shown that stimulated emission of harmonics creates additional phase independence of the ring cavity. These effects are observed over a wide range of laser parameters. The theory is satisfactorily confirmed by experimental data. Figure 1, reference 1 Russian.

[26-6610]



# A CO<sub>2</sub> PULSE LASER WITH PRE-IONIZATION BY UV EMISSION FROM CAPILLARY-ARC DISCHARGES

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 50, No 12, Dec 80  
pp 2567-2572 manuscript received 15 Jan 80

KUCHINSKIY, A. A., RODICHKIN, V. A. and SMIRNOV, V. A., Scientific Research Institute of Electrophysical Apparatus imeni D. V. Yefremov

[Abstract] An experimental study is done on the lasing characteristics of a CO<sub>2</sub> laser with UV pre-ionization by a discharge system in which the main discharge takes place between a copper anode with specially shaped edges and a grid cathode. The inter-electrode spacing is 2 cm, and 2.5 cm from the grid is a pre-ionizer consisting of 28 capillary-arc sources (ceramic tubes). This type of system produces a volumetric discharge over a wide range of pressures and gas mixtures. An investigation is made of the way that the limits of stability of the volumetric discharge depend on these parameters. The results of the study show that such a discharge system can be used for effective pumping of a CO<sub>2</sub> laser. Optimization of the laser parameters yields an energy output of more than 20 joules per liter in a nitrogen-containing mixture, and more than 6 joules per liter in a mixture with helium. By using breakdown at the focus of a lens, a pulse with energy of about 0.5 J is obtained with half-amplification duration of about 50 ns. This emission can be used with subsequent amplification for experiments on plasma heating in traps with magnetic containment. Figures 7, references 10: 5 Russian, 5 Western.  
[27-6610]

## FEASIBILITY OF A LOW-TEMPERATURE GAMMA LASER

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 79, No 3(9), Sep 80 pp 730-750 manuscript received 24 May 79 after revision 5 Feb 80

KARYAGIN, S. V., Institute of Chemical Physics, USSR Academy of Sciences

[Abstract] When interference such as spontaneous decay, overheating and so on is taken into consideration, realistic pumping thresholds make the gamma laser unrealizable even if it is assumed that the intensity of activations is infinite. The author proposes methods of overcoming these in situ difficulties by counter-acting interference through anomalous dilution of working nuclei, narrowing lines without external action, two-stage pumping with implantation of excited nuclei in the first target, and pulsed separation of the processes of activation, inversion and lasing by radio or optical methods, as well as by using high-speed active and passive resonant shutters or systems of such shutters combined with

a controllable traveling pumping region, and finally by using ring amplification techniques. By eliminating in situ difficulties, these steps bring about conditions for different types of controllable pumping and gamma lasing, and increase the number of workable gamma-laser isotopes. These techniques can be used in part in gamma spectroscopy and in the optical band. A two-stage generalized model is proposed for comparing various single-stage and two-stage pumping schemes. The possibility of  $\gamma$ -pulse lasing is predicted. Comparative numerical estimates of gamma laser parameters are given for six isotopes. The author expresses gratitude for discussions with V. I. Gol'danskiy, Yu. A. Il'inskiy, A. V. Andreyev, V. G. Pokazan'yev, N. M. Kuznetsov, L. A. Zaytseva, A. A. Landin, V. V. Pomortsev, N. N. Delyagin, R. N. Kuz'min, M. A. Kumakhov, L. A. Rivlin and participants in the Moscow State University Seminar on the Gamma Laser Problem in memory of R. V. Khokhlov. Figures 5, references 33: 25 Russian, 1 Bulgarian, 2 Romanian, 5 Western.  
[21-6610]

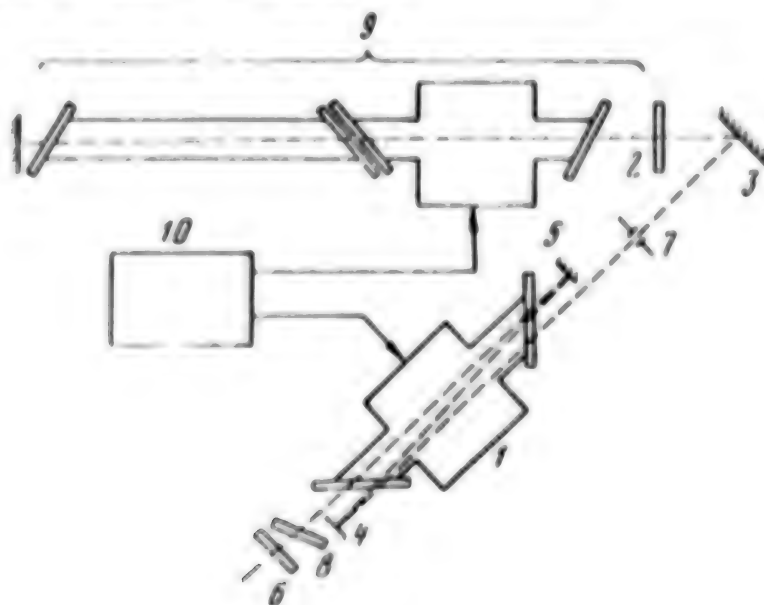
UDC 621.373.8.038.823

#### STIMULATION OF EMISSION WITH WAVELENGTH OF $4.3 \mu\text{m}$ IN A TE $\text{CO}_2$ LASER

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 255, No 6, 1980 pp 1353-1356  
manuscript received 1 Jul 80

BERTEL', I. M., PETUKHOV, V. O., STEPANOV, B. I., academician, BSSR Academy of Sciences, TRUSHIN, S. A. and CHURAKOV, V. V., Institute of Physics, BSSR Academy of Sciences, Minsk

[Abstract] Emission is stimulated in bands  $(10^01, 02^00)_{I,II} - (10^02, 02^00)_{I,II}$  of the  $\text{CO}_2$  molecule (wavelength  $\lambda = 4.2-4.4 \mu\text{m}$ ) in a TE  $\text{CO}_2$  laser with pressure of the active medium of about 0.5 atmosphere.





A diagram of the experimental facility is shown in the figure. Cell 1 with discharge volume of  $2 \times 4 \times 50$  cm contains the active medium for the 4.3-micrometer laser with transverse excitation and preionization by ultraviolet light. The cavity is formed by five mirrors 2-6. Totally reflecting mirrors 3-5 ensure three passes of the radiation in cell 1. Mirrors 2 and 6 have reflectivity of about 75%. Iris 7 narrows the beam inside the cavity to  $0.5 \text{ cm}^2$ .  $\text{CaF}_2$  plate 8 suppresses lasing in the fundamental band of  $10.6 \text{ }\mu\text{m}$ . Germanium mirror 2 is also the output mirror of TEA  $\text{CO}_2$  laser 9 that emits on line 10P (15) of the second band of the sequence. Pulse duration of laser 9 is about 200 ns. The intensity of pumping radiation inside the cavity of the 4.3-micrometer laser is about  $1 \text{ MW/cm}^2$ . Block 10 is added for delay between the discharges in the cells of the 4.3-micrometer laser and laser 9. Stimulated emission on  $4.3 \text{ }\mu\text{m}$  begins at the instant of maximum pumping intensity. Peak lasing power is about  $10 \text{ kW/cm}^2$  with half-amplitude pulse duration of about 50 ns. The results show that it is feasible in principle to produce powerful TEA  $\text{CO}_2$  lasers that are tunable over a band of  $4.2\text{-}4.4 \text{ }\mu\text{m}$ . Figures 4, references 6: 2 Russian, 4 Western.  
[41-6610]

UDC 621.378.33

#### GAS LASERS WITH INCOHERENT OPTICAL PUMPING

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 44, No 7, Jul 80 pp 1516-1524

BASOV, N. G., ZUYEV, V. S., MIKHEYEV, L. D. and STOYLOV, Yu. Yu., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] The text of a report presented at the Second All-Union Conference on Laser Optics held in Leningrad, January 1980. A survey of methods of optical pumping by incoherent light sources (flash tubes and open high-current discharges). An analysis is made of lasing mechanisms using molecular absorption of gases on bound-free, bound-bound and free-bound transitions with consideration of products formed by photodissociation and secondary chemical reactions. The principles of flash photolysis and excimer lasers are explained. An examination is made of the techniques used for increasing the efficiency of incoherently pumped gas lasers. The feasibility of using organic dyes in the gas phase as an active medium in lasers with incoherent pumping is discussed. Some advantages of optical pumping over electronic pumping are pointed out. Figures 4, references 34: 21 Russian, 13 Western.  
[49-6610]

LASERS EMITTING ON A WAVELENGTH OF 16  $\mu\text{m}$ 

Moscow IZVESTIYA AKADEMII NAUK SSSR: SERIYA FIZICHESKAYA in Russian Vol 44, No 7, Jul 80 pp 1525-1534

KARLOV, N. V., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] The text of a report presented at the Second All-Union Conference on Laser Optics held in Leningrad, January 1980. The author discusses the use of tunable pulse lasers that emit in the 16  $\mu\text{m}$  wavelength range for separation of isotopes by infrared dissociation of polyatomic molecules as exemplified by  $\text{UF}_6$ , which has a frequency of asymmetric stretching vibrations corresponding to this wavelength range. Different methods of achieving stimulated emission in the middle IR band by gas-discharge and nonlinear optics techniques are enumerated, and a detailed analysis is made of  $\text{CO}_2$ ,  $\text{CF}_4$  and Raman lasers. It is concluded that two laser methods hold the greatest promise for retention of the important properties of the  $\text{CO}_2$  laser on longer wavelengths: optical pumping of actual levels that takes place with loss of coherence of the pumping radiation, and optical pumping of the nonlinear process of induced scattering of light, in which pumping coherence is essential. The former method is now at the most advanced stage in the  $\text{CF}_4$  laser. However, the second method may have a better outlook in the Raman hydrogen laser. Figures 7, references 20:

14 Russian, 6 Western.

[49-6610]

UDC 535.2+621.373:535

## EXPERIMENTAL INVESTIGATION OF THE CURVATURE OF THE MIDDLE PHASE FRONT OF A LASER BEAM IN A TURBULENT ATMOSPHERE

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 49, No 3, Sep 80 pp 595-598  
manuscript received 31 Aug 79

BELEN'KIY, M. S., BORONOV, V. V., GOMBOYEV, N. Ts., MIRONOV, V. L. and TRUBACHEYEV, E. A.

[Abstract] Atmospheric turbulence can cause such effects as loss of spatial coherence and turbulent broadening of laser beams, mottled structure and random transverse displacements of the beam as a whole. Theory predicts that the presence of a medium should cause additional curvature of the middle phase front of a laser beam propagating in a turbulent atmosphere. It has been shown that the radii of curvature of an unbounded plane wave and a spherical wave in a turbulent atmosphere remain the same as in a vacuum, while the radius of curvature of the middle phase front of a spatially bounded beam depends on the

turbulent conditions of propagation, and in the region of strong fluctuations of intensity is  $1/3$  the value for the same beam in vacuum, and  $2/3$  the value for a spherical wave. In this paper the authors give the theory for determining the radius of curvature of the middle phase front of a laser beam in a turbulent atmosphere by an autocollimation method, and experimentally verify the predicted effect of additional curvature of the middle phase front in a real atmosphere. Figure 1, references 10 Russian.  
[57-6610]

## NATURE OF A HELICAL MHD DYNAMO INSTABILITY

Riga MAGNITNAYA GIDRODINAMIKA in Russian No 2, Apr-Jun 80 pp 10-16 manuscript received 27 Sep 79

GAYLITIS, A. and FREYBERG, Ya.

[Abstract] An examination is made of the analogy between two instabilities that show up in a flow as intensity increases: hydrodynamic instability of a laminar flow resulting in turbulence, and dynamo instability resulting in a magnetically active state of flow of an electrically conductive fluid. For a helical dynamo model this analogy is expressed in the similarity of the solutions to those for hydrodynamic stability of a plane-parallel flow. On the basis of this analogy, the authors apply the approach used in studying a hydrodynamic instability to investigate a dynamo instability in an axisymmetric helical model of the MHD dynamo that is homogeneous along the axis of symmetry. An analysis is made of temporal and spatial development of the starting field and the evolution of localized perturbations. It is found that in the case of helical motion in one direction the instability is only convective, while opposed flows may lead to absolute instability as well. The characteristics of such an instability are numerically calculated in a cylindrical model with three regions and rigid helical motion. Figures 5, references 9: 8 Russian, 1 Western.  
[55-6610]

THE LAW OF CONSERVATION OF ENERGY AND UNIQUENESS OF CLASSICAL SOLUTIONS OF  
NONLINEAR MHD PROBLEMS

Riga MAGNITNAYA GIDRODINAMIKA in Russian No 2, Apr-Jun 80 pp 78-80 manuscript  
received 25 Apr 79

BERSHADSKIY, A. G.

[Abstract] Equations that describe the motions of a viscous incompressible  
conductive fluid in an electromagnetic field are nonlinear, and therefore it  
cannot be assumed a priori that the solution of such a problem that is continuous  
together with its first derivatives is unique. The author considers such a  
solution of the Navier-Stokes-Maxwell problem, and shows that the law of con-  
servation of energy implies uniqueness of such solutions in bounded regions.  
Certain additional constraints are required to make the result valid for un-  
bounded regions. The author thanks A. B. Kapusta for assistance. References  
4 Russian.  
[55-6610]

## NUCLEAR PHYSICS

### THEORETICAL STUDY OF THE HYDRODYNAMICS OF SPHERICAL TARGETS WITH CONSIDERATION OF THE REFRACTION OF LASER RADIATION

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 79, No 3(9), Sep 80 pp 837-849 manuscript received 10 Dec 79, after revision 29 Apr 80

AFANAS'YEV, Yu. V., GAMALIY, Ye. G., DEMCHENKO, N. M., KROKHIN, O. N. and ROZANOV, V. B., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] One of the problems that arises in laser driven fusion is determination of the fraction of beam energy expended in heating and imploding the target. The problem has been analyzed for the case of a flat target with normal incidence of the laser beam [see Yu. V. Afanas'yev et al., ZhETF, Vol 72, p 170, 1977]. The authors use a similar approach in this paper for the case of a spherical target. Since the focusing optical system has to take up a solid angle of less than  $4\pi$ , it is impossible to get absolutely symmetric spherical irradiation in experiments on spherical heating. Under such conditions an important effect that might appreciably increase losses of laser energy is refraction of laser radiation in the corona of the target. Because of the difficulty of solving the complete three-dimensional problem of target dispersal, the average energy release is considered, assuming that dispersal of the target is spherically symmetric. The process of interaction of radiation with matter is described by Maxwell's equations for heating radiation and equations of hydrodynamics with electronic thermal conduction. A model is proposed that accounts for mechanisms of absorption: inverse bremsstrahlung, and the anomalous and resonant mechanisms. The given equations are numerically solved for glass shells with diameter of about  $100\ \mu\text{m}$  and laser pulse power of about  $5 \cdot 10^{10}\ \text{W}$  at a duration of about 2 ns. Principal emphasis is placed on the study of absorption of laser radiation in the target. The results are compared with experimental data. The authors thank A. S. Shikanov and A. A. Rupasov for constructive discussions. Figures 8, references 16: 8 Russian, 8 Western.

[31-6610]

## ON THE MECHANISM OF GENERATION OF HOT ELECTRONS IN A LASER PLASMA

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 79, No 3(9), Sep 80 pp 850-856 manuscript received 17 Jan 80

LAEKSANDROV, V. V., KOVAL'SKIY, N. G. and SILIN, V. P.

[Abstract] Laser plasma research shows that hot epithermal electrons are formed by laser radiation in the plasma corona at the surface of an irradiated target. This is important because the amount of laser energy needed in a demonstration experiment on inertial fusion as well as the design of the target depend considerably on how much heating of the inner regions of a thermonuclear target can be expected due to penetration and absorption of epithermal electrons and associated hard x-rays. There are two possible mechanisms of generation of epithermal electrons: Cerenkov absorption of electronic Langmuir plasma waves that arise in the corona under the action of laser radiation; a reduction in electronic heat transfer compared with collisionless Knudsen transfer resulting in overheating of the plasma corona where the absorption of laser radiation is appreciable. The authors report on experiments to determine which mechanism actually arises. The experiments involve interaction of powerful neodymium laser pulses of 3.5 ns duration with flat targets of different materials over a range of light flux densities of  $10^{12}$ - $10^{14}$  W/cm<sup>2</sup>. A correlation is established between generation of a harmonic of  $3/2\omega_0$  and a "hard" component showing up in the x-ray spectrum. Analysis of the resultant data shows that most of the electrons in the region of  $1/4n_{cr}$  have a temperature corresponding to the "soft" component in the x-ray spectrum. The generation of hot electrons is attributed to development of a two-plasmon parametric instability (the mechanism of Cerenkov absorption of Langmuir waves). Figures 5, references 9: 7 Russian, 2 Western.  
[31-6610]

## RADIAL DISTRIBUTION OF THE CONCENTRATION OF OXYGEN NUCLEI IN THE PLASMA OF THE TOKAMAK-10

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 32, No 9, 5 Nov 80 pp 557-560 manuscript received 1 Jul 80

ZINOV'YEV, A. N., KOROTKOV, A. A., KRZHIZHANOVSKIY, Ye. R., AFROSIMOV, V. V. and GORDEYEV, Yu. S., Physicotechnical Institute imeni A. F. Ioffe, USSR Academy of Sciences

[Abstract] The concentrations of ions and impurities and their distributions must be measured to analyze the energy balance of a plasma and study diffusion. Since the most important light impurities (carbon and oxygen) in the central zone of tokamaks are in the form of nuclei and are inaccessible to conventional spectroscopic methods of measurement, it is important to develop direct local



methods of checking the content of impurity nuclei. This paper is a report on the first attempt to use the method of corpuscular-spectroscopic diagnosis for measuring the radial distribution of concentration of oxygen nuclei in a tokamak plasma. The technique involves probing the plasma with a beam of fast hydrogen atoms. When the atoms of this beam collide with the oxygen nuclei, electron capture produces excited hydrogen-like ions  $O^{7+*}$ , accompanied by additional emission on the characteristic lines of these ions ( $19 \text{ \AA}$ ). The detector was a secondary photomultiplier with a CsI photocathode having a quantum yield of 30% for this line. The sensitivity of the band detector was  $8 \cdot 10^{-4}$  pulse per photon. The results show that there is no appreciable accumulation of oxygen in the plasma on the stationary stage of discharge. The diffusion lifetime of oxygen nuclei is calculated to be 14 ms. This result indicates that there must be some mechanism that effectively removes the oxygen from the plasma. The authors thank the collective of the T-10 tokamak facility for assistance with the work, and in particular V. A. Krupin and V. I. Bugar' for helping to check the detector calibration, as well as A. V. Izvozhikov and Ye. L. Berezovskiy for setting up and aligning the atom injector. Figures 2, references 7: 5 Russian, 2 Western.

[36-6610]

#### ON USING CONVERSION OF LASER RADIATION TO FAST ELECTRONS IN THE PROBLEM OF LASER FUSION

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian  
Vol 33, No 1, 5 Jan 81 pp 19-23 manuscript received 10 Nov 80

VOLOSEVICH, P. P. and ROZANOV, V. B.

[Abstract] The authors consider the feasibility of choosing a mode of irradiating targets with long-wave radiation from  $CO_2$  lasers so that fast electrons produced in the corona will have sufficient energy that the amount released in the outer part of the vaporized shell of the target reaches layers with density beyond the critical level. The size of such a region of energy release can be optimized for implosion and subsequent combustion of the target without any preheating of the thermonuclear fuel. Calculations to verify the predicted effects were done for a target of DT ice and a light ablator with aspect ratio of 100 and absorbed laser radiation of about 100 kJ. The results show that the effect of deep penetration of electrons takes place with reasonable conditions of  $CO_2$  laser irradiation of the target, which should make long-wave lasers competitive with the shortwave versions of laser fusion reactors. The authors thank N. N. Demchenko, Ye. G. Gamaliy and Yu. V. Afanas'yev for discussing the problems of this research. Figures 3, references 12: 3 Russian, 9 Western.

[40-6610]



## ESTIMATION OF THE PARAMETERS OF A 120-cm CYCLOTRON WITH CONVERSION TO AVF OPERATION

Kiev OTSENKA PARAMETROV 120-SANTIMETROVOGO TSIKLOTRONA PRI PEREVODE V  
IZOKHRONNYY REZHIM in Russian Preprint KIYaI-79-9, 1979 (signed to press  
18 Oct 79, manuscript received 10 Jul 79) pp 1-24

BEL'SKIY, Yevgeniy Mikhaylovich, BYKOV, Valeriy Ivanovich, LINEV, Aleksandr  
Pedorovich and OLEYNIK, Yevgeniy Yevgen'yevich, Nuclear Research Institute,  
USSR Academy of Sciences, Kiev

[Abstract] The paper gives the calculation of parameters and sector shine for converting the U-120 cyclotron to the U-120 M sector-focused cyclotron. It is shown that the updated version can accelerate a much wider spectrum of particles. In all proposed versions of conversion of these cyclotrons to isochronous operation the ion energy is controlled by using concentric coils to form the appropriate magnetic field configurations. A much simpler method is provided by particle extraction with an ion beam stripper. Estimates made in this research show that conversion to AVF operation would require six auxiliary magnet coils on the pole tips with height of the order of 25 mm to trim the field shape. A new dee will also be needed. The present instrumentation can be used for magnetic field measurements without much modification. The use of an ion beam stripper will provide nearly 100% extraction of particles. The proposed modifications would result in only a slight deterioration of beam quality (5-7% loss in monoenergetic properties of the beam). Figures 6, references 13: 5 Russian, 8 Western.

[51-6610]

## OPTICS AND SPECTROSCOPY

### NONLINEAR DEFOCUSING OF A FOCUSED BEAM: THIN RAY FROM THE FOCUS

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian  
Vol 33, No 1, 5 Jan 81 pp 48-51 manuscript received 27 Nov 80

ASKAR'YAN, G. A. and MUKHAMADZHANOV, M. A., Physics Institute imeni P. N. Lebedev,  
USSR Academy of Sciences

[Abstract] In most media thermal nonlinear refraction causes defocusing of a beam. The authors investigate the feasibility of using nonlinear defocusing to produce thin rays from the focus of a beam in a layer of medium. A lens was used to focus laser radiation in a layer of water, alcohol or plexiglas, and the distribution of intensity of the transmitted light was measured for different powers and different positions of the focus. Distribution was studied visually, photographically and by photomultiplier. A bright spot was observed on the axis many times the intensity of the light without nonlinear refraction. The dynamics of formation of this narrow ray in time are studied. The results of similar experiments with a light spark can be explained by the effect of defocusing of light in the spark plasma. Figures 3, references 8: 4 Russian, 4 Western.

[40-6610]

UDC 537.523

### OPTICAL DISCHARGES

Moscow USPEKHI FIZICHESKIKH NAUK in Russian Vol 132, No 3, Nov 80 pp 549-581

RAYZER, Yu. P., Institute of Problems of Mechanics, USSR Academy of Sciences

[Abstract] An analysis is made of processes that take place under the action of laser radiation: breakdown of gases, and maintenance of equilibrium and nonequilibrium plasmas. It is shown that these gas-discharge processes differ only in the frequency of the stimulating emission from analogous phenomena in a dc electric field, at radio frequencies and in microwaves. The history of

optical breakdown in gases is covered from its discovery by Maker, Terhune and Savage in 1963 through the present stage of generating sparks up to 8 m in length, and discharge ionization by a laser spark. Difficulties that must be surmounted for maintaining a steady-state nonequilibrium plasma by light are discussed. Steady-state maintenance of an equilibrium plasma is analyzed in detail with consideration of a continuous optical discharge and the optical plasmotron, evaluation of the plasma temperature and the threshold light intensity, the reasons for the unusually high temperatures observed in optical discharges and radiation losses. The problems of measuring temperatures and thresholds in the equilibrium plasma are discussed, and the upper limit of power is estimated. An examination is made of mechanisms of propagation of optical discharges. Some practical applications of optical discharges are explained, including the use of an optical plasmotron as a spacecraft propulsion system, a rocket engine that uses repeated flashes of an optical breakdown, and the conversion of luminous energy to electricity. Figures 16, references 55: 31 Russian, 24 Western.  
[42-6610]

UDC 533.35+539.184

#### DOPPLER-FREE NONLINEAR PROCESSES IN STRONG OPTICAL FIELDS

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 49, No 3, Sep 80 pp 617-622  
manuscript received 21 Sep 79

POPOV, A. K. and SHALAYEV, V. M.

[Abstract] It has been shown that Doppler-free processes take place in strong fields even when they are impossible in weak fields. This is true especially of processes like Raman scattering. Previous research has covered the change in shape of the weak-field absorption and emission line in the presence of a strong field. In this paper, the results are extended to the case in which an atomic system can be strongly perturbed by either field. The analysis is based on a model of quasi-resonant interaction of two strong monochromatic fields with a three-level system, assuming that each field interacts with only one transition. It is shown that as pumping intensity increases, the compensation of Doppler broadening of a two-photon transition in opposed waves vanishes. On the other hand, narrow Doppler-free resonance is possible in a radiation field with two different frequencies, and this is true for Raman scattering as well as for two-photon absorption. The probability of Doppler-free transitions can be increased by choosing the pumping frequencies to minimize detuning relative to the intermediate level. Conditions are formulated that must be satisfied to get

narrow Doppler-free resonances in fields of different frequencies. An investigation is made of the part played by Doppler-free transitions in resonant four-photon parametric interactions in gases. It is demonstrated that in these processes the effect can result in an increase in nonlinear susceptibility and the coefficient of radiation conversion by several orders of magnitude. Estimates are made of conditions for observing the effect in sodium vapor, and it is shown that Doppler-free nonlinear processes should be observable at pumping intensities of the order of  $1 \text{ kW/cm}^2$ . Figure 1, references 4: 1 Russian, 3 Western. [57-6610]

UDC 621.371.165:533.9.082.7

DIPOLE RESONANCE OF AN ELLIPTICAL PLASMA CYLINDER IN A DIELECTRIC SHELL

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 51, No 1, Jan 81 pp 172-175  
manuscript received 2 Jan 80

BRYUKHOVETSKIY, A. S. Institute of Radiophysics and Electronics, Ukrainian SSR  
Academy of Sciences, Khar'kov

[Abstract] The diffraction of a plane electromagnetic wave impinging normally on the generatrix of an elliptical dielectric cylinder was considered in approximation of a cold plasma. Debye potentials for the field inside the shell wall are introduced. These potentials contain Bessel and Neumann functions in the expansions with respect to wave functions of a circular cylinder. An expression is derived for the field strength in the plasma. It is shown that conditions can be arranged so that the opposing effects of radiation damping and the dielectric shell cancel each other, resulting in a ratio of plasma frequency to incident frequency equal to that of a plasma cylinder without the shell. The field in the plasma is reduced by either increasing plasma dimensions or increasing shell thickness. Figures 2; references 5: 4 Russian, 1 Western. [46-6521]

# INTERFERENCE-HOLOGRAPHIC INVESTIGATION OF A SUPERSONIC PLASMA JET OF PULSED DISCHARGE

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 51, No 1, Jan 81 pp 68-72  
manuscript received 11 Feb 80

BURMAKOV, A. P. and NOVIK, G. M., Scientific Research Institute of Applied Physical Problems attached to the Belorussian State University imeni V. I. Lenin

[Abstract] A pulsed underexpanded plasma jet was diagnosed by holographic interferometry in real time with high spatial and time resolution. A ruby laser was used as the probing radiation source and frame scanning of the jet interferograms was recorded by a high-speed camera during free lasing. The equilibrium component of the plasma composition was calculated for the pressures and temperatures most probable in the structure. Electrons and copper atoms make the greatest contribution to plasma refraction and the total contribution of copper ions and carbon and fluorine atoms does not exceed 25 percent. The axial temperature distributions and flow densities were found for the most typical stages of plasma flows corresponding to formation of a Mach disc and periodic structure in the jet. Temperature nonequilibrium of the plasma exists in front of the Mach disc. Figures 4; references 17: 15 Russian, 2 Western.  
[46-6521]

UDC 533.9.08

# DETERMINING MAGNETIC FIELD STRENGTH IN A HYDROGEN PLASMA FROM RESONANT FARADAY ROTATION OF THE PLANE OF LIGHT POLARIZATION

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 33, No 6, Dec 80  
pp 1019-1023 manuscript received 20 Feb 80

ADONTS, G. G., MURADYAN, A. Zh. and OGANESYAN, K. B.

[Abstract] A theoretical investigation is made of the feasibility of determining magnetic field strength in a hydrogen plasma from resonant Faraday rotation of the plane of light polarization by residual neutral atoms or by injected impurity atoms. In the situation where the light interacts with residual neutral atoms, it is shown that splitting and displacement of the energy levels of these atoms in the magnetic field can lead to circular dichroism and a difference in circular dispersion of the index of refraction. Based on analysis of the change in polarization of the probe signal, an estimate is made of the angle of turn of the plane of polarization under typical experimental conditions. The result shows that the minimum density of hydrogen atoms required for determining a magnetic

field strength of  $2.4 \cdot 10^6$  A/m [30 kOe] is  $6 \cdot 10^{11}$ – $6 \cdot 10^{12}$  cm<sup>-3</sup>. In the case where field strength is determined by this method with injection of neutral cesium atoms, the density required is about  $10^9$  cm<sup>-3</sup> for determining a field of the same strength under the same typical conditions. The authors thank T. A. Papazyan for constructive discussions during the course of the work. References 5 Russian. [47-6610]

#### SOME PECULIARITIES OF A GAS-DISCHARGE ION SOURCE

Yerevan UCHENYYE ZAPISKI YEREVANSKOGO GOSUDARSTVENNOGO UNIVERSITETA: YESTESTVENNYE NAUKI in Russian No 1, 1980 pp 78-84 manuscript received 25 Jun 79

BABERTSYAN, R. P., BADALYAN, E. S. and KHACHATRYAN, Zh. B., Department of General Physics, Yerevan State University

[Abstract] Experiments are done to determine the parameters of an ion source with maximum current and minimum beam divergence. The axial component of the ion current is singled out from the total beam current to find the conditions under which the region of intense ionization is the paraxial region of the ion source. High-energy electrons in the ion beam were suppressed by a controlling electrode with voltage variable from 0 to 200 V relative to the cathode. It was found that the most effective ion source in magnetic fields of the order of 0.11 T is a cell with anode diameter of 13 mm. An anode with diameter of 15 mm may be an effective ion pump for a wide range of magnetic fields. The larger the number of ions that have high velocity when they reach the central part of the cathode, the greater will be the sputtering ratio of the cathode material, and hence the greater will be the evacuation rate. Figures 6, references 6: 4 Russian, 2 Western. [61-6610]



# INVESTIGATION OF THE DYNAMICS OF PLASMA PRODUCTION AND FORMATION OF A COMPRESSION REGION IN A GASEOUS MAGNETOPLASMA COMPRESSOR

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 33, No 4, Oct 80  
pp 629-633 manuscript received 19 Sep 79

ASTASHINSKIY, V. M., BAKANOVICH, G. I. and MIN'KO, L. Ya.

[Abstract] The compression region of a gas magnetoplasma compressor is studied by high-speed photography and spectrography. The discharge device in the magnetoplasma compressor consisted of an inner conical cathode surrounded by an anode made up of 12 rods uniformly spaced. The energy source was a capacitor bank with discharge through a vacuum spark gap. The bank was charged to 5 kV, and maximum discharge current was 350-400 kA. The capacitance of the bank was 2400 F, plasma-forming gas was air, pressure was 1-5 mm Hg. The temperature and concentration of electrons were determined from the relative intensity and broadening of spectral lines of the NiI ions as measured on motion picture frames of the plasma emission spectra. Transverse photoscans made with the camera slit normal to the axis of the discharge device showed that the compression region undergoes radial oscillations during the settling stage, and these oscillations are intensified as the pressure is reduced. The compression region becomes macrostable within 30  $\mu$ s after the beginning of the discharge current. In continuous photoscans with the slit oriented parallel to the discharge axis, the compression region reveals a jet structure. Typical plasmoid velocity at 1 mm Hg is about  $5 \cdot 10^6$  cm/s, which falls to about  $2 \cdot 10^6$  cm/s at 5 mm Hg. The compression region collapses after about 70  $\mu$ s from the beginning of the discharge current. There is little longitudinal change in temperature over the lifetime of the plasma compression region. The temperature increases from 30,000 K to 50,000 K with increasing initial pressure from 1 to 5 mm Hg. Electron concentration reaches a maximum of about  $10^{18}$  cm<sup>-3</sup> at a distance of 3-4 cm from the end of the cathode. Figures 4, references 7 Russian.  
[53-6610]

## DEVELOPMENT OF LANGMUIR OSCILLATIONS WITH TRANSVERSE MOTION OF PLASMA IN A MAGNETIC FIELD

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 255, No 5, 1980 pp 1095-1098  
manuscript received 4 Aug 80

TRUSHIN, S. A. and SHOLIN, G. V., Institute of Atomic Energy imeni  
I. V. Kurchatov, Moscow

[Abstract] Although considerable experimental material has been accumulated in confirmation of detailed theoretical calculations in the area of transverse magnetoacoustic waves of finite amplitude, the emphasis has been on experiments that fit into existing models of collisionless relaxation, and specifically development of ionic-acoustic instability. Up until now there has been no satisfactory interpretation of intense Langmuir noises that have been experimentally observed in nonlinear magnetoacoustic waves and in the interaction of plasmoids. In this paper it is shown that the conventional a priori assumption of quasineutrality of a plasma is satisfied only on the average over a large number of Langmuir oscillations, whereas charge separation on scales of  $u/\omega_{pe}$  (where  $u$  is a wave velocity) may be practically total. The analysis is based on consideration of a magnetoacoustic wave propagating perpendicular to a magnetic field in the two-fluid hydrodynamic approximation without assuming quasineutrality, but with restriction to the case where the Langmuir frequency  $\omega_{pe}$  is much greater than the electron-cyclotron frequency  $\omega_e$ . No a priori assumptions are made on the smallness of the ratio  $m_e/m_i$ . A solution of wave type is found that depends only on the variable  $\xi = x - ut$  for a system of equations that includes Maxwell's equations, equations of motion and continuity for the electrons and ions, and the electric field equation. It is shown that when a plasma moves across a magnetic field of intensity  $B$ , Langmuir noises develop with energy density  $\frac{\langle E^2 \rangle}{8\pi} \approx \frac{m_e}{m_i} \frac{B^2}{8\pi}$ . The development of Langmuir noises on the

wavefront leads to broadening of the profile of the magnetic field to typical dimensions of  $\langle \delta_B \rangle \approx (m_i/m_e)^{1/2} c/\omega_{0p}$ , where  $\omega_{0p} = \sqrt{4\pi e^2 n_0/m_e}$ ,  $n_0$  is the unperturbed particle density. References 15: 10 Russian, 5 Western.  
[20-6610]

## CONCERNING THE SKIN EFFECT IN RELSOTRONS AND PULSED PLASMA ACCELERATORS

Novosibirsk IZVESTIYA SIBIRSKOGO OTDELENIYA AKADEMII NAUK SSSR: SERIYA  
TEKHNICHESKIKH NAUK in Russian No 13(328), Issue 3, Oct 80 pp 13-15

GOROKHOVSKIY, V. I. and URYUKOV, B. A., Institute of Superhard Materials, UkSSR  
Academy of Sciences, Kiev

[Paper presented at the Eighth All-Union Conference on Low-Temperature Plasma  
Generators, 2-4 July 1980, Novosibirsk]

[Abstract] Previous research by Uryukov et al. [see V. G. Popenko, M. P. Strongin, B. A. Uryukov, "Investigation of High-Current Pulsed Discharge in  $E \times H$  Field," Sixth All-Union Conference on Low-Temperature Plasma Generators, Frunze, 1974] dealt with the problem of the skin effect as the electric field moves along the rails of the relsotron. In this effect, when the speed of the arc spot along the rails of the relsotron is high enough, the current inside the conductor does not have time to fill the entire cross section, and approaches the surface, producing a kind of skin layer. The effect becomes even more important in pulsed plasma accelerators where the current reaches  $10^6$  A, and the velocity of discharge motion is more than  $10^4$  m/s. In the present paper, a solution is found for the problem with consideration of Hall current, which intensifies the effect. The flow of electric current is described in the laboratory coordinate system by Maxwell's equations and Ohm's law with consideration of the electron concentration due to the properties of the metal. The boundary value problem for the thickness of the skin layer and the current density in a moving coordinate system is solved numerically as a Cauchy problem. Figures 2, references 5 Russian.

[28-6610]

## VIOLATION OF THERMODYNAMIC EQUILIBRIUM IN ELECTRIC-ARC PLASMA SOURCES

Novosibirsk IZVESTIYA SIBIRSKOGO OTDELENIYA AKADEMII NAUK SSSR: SERIYA  
TEKHNICHESKIKH NAUK in Russian No 13(328), Issue 3, Oct 80 pp 15-18

ZHIZHNIKOV, G. M., LUK'YANOV, G. A. and SAKHIN, V. V., Leningrad Institute of  
Mechanics

[Paper presented at the Eighth All-Union Conference on Low-Temperature Plasma  
Generators, 2-4 July 1980, Novosibirsk]

[Abstract] An engineering method is proposed for calculating the parameters of a plasma, and the results are compared with experimental data. The usual system of equations defining the parameters of a thermodynamically equilibrium plasma is supplemented by an equation for nonisothermicity, based on the following assumptions: 1. the plasma parameters and electric field are homogeneous in the region of the arc discharge; 2. the plasma is ideal, two-temperature and in ionizational equilibrium, being made up of electrons and heavy particles with maxwellian velocity distribution and known temperatures of the two components; 3. the gap between the temperatures of electrons and ions is due only to the electric field. The proposed system of equations is solved for pressures of 0.1-1.0 bar, and ion temperatures of  $(2-20) \cdot 10^3$  K for a helium-argon plasma. Results are given for electron concentration and nonisothermicity as functions of the temperature at different pressures. The data agree satisfactorily with experiments on a DC plasmatron with helium as the working fluid. Figures 4, references 6 Russian.

[28-6610]

INVESTIGATION OF THE NONEQUILIBRIUM PROPERTIES OF AN ARC-DISCHARGE PLASMA IN A MIXTURE OF  $N_2$ - $CO_2$ -He BY THE METHOD OF LASER PROBING

Novosibirsk IZVESTIYA SIBIRSKOGO OTDELENIYA AKADEMII NAUK SSSR: SERIYA  
TEKHNICHESKIKH NAUK in Russian No 13(328), Issue 3, Oct 80 pp 62-64

ABAKUMOV, B. V., KUROCHKIN, Yu. V., LAZUTKIN, O. N., PAKHOMOV, N. Yu.,  
PUSTOGAROV, A. V., UKOLOV, V. V. and SHAN'GIN, O. S.

[Paper presented at the Eighth All-Union Conference on Low-Temperature Plasma  
Generators, 2-4 July 1980, Novosibirsk]

[Abstract] Direct proof of deviations from equilibrium in a high-pressure arc discharge plasma, especially in vibrational degrees of freedom of the particles,

is inverse population of energy levels of  $\text{CO}_2$  molecules when they are injected into the peripheral region of the discharge as a result of resonant exchange of vibrational energy quanta between an antisymmetric  $\text{CO}_2$  mode and vibrationally excited nitrogen. This article describes experiments in which population inversion of the working levels of carbon dioxide molecules is detected by measuring the amplification factor of probing  $\text{CO}_2$  laser radiation. The amplification factor was measured in the arc discharge in a plasmatron channel with stabilization by blowing a mixture of 96%  $\text{N}_2$  and 2%  $\text{CO}_2$  through the porous walls of the channel. Measurement was by two-beam photometry. At a pressure of 1-4 atmospheres in the channel, the weak-signal gain of a probing laser on a wavelength of  $10.6 \mu\text{m}$  was  $1-3 \text{ m}^{-1}$ . Relations are given for the gain as a function of pressure, discharge current and flowrate of the components. The results show that a dense  $\text{CO}_2$ -based inverse medium is produced directly in the channel of the plasmotron. Figures 3; references 3 Russian.

[28-6610]

UDC 533.9:546.217

#### SPECTRAL PROPERTIES OF A DENSE (NONIDEAL) AIR PLASMA

Leningrad OPTIKA I SPEKTROSKOPIYA in Russian Vol 49, No 3, Sep 80 pp 469-477  
manuscript received 20 Aug 79

ANDREYEV, S. I. and GAVRILOVA, T. V.

[Abstract] The spectral properties of air plasma were experimentally studied at temperatures of 17,000-20,000 K and pressures of 40-150 atmospheres. This is the range of parameters where effects due to nonideality of the plasma can be investigated. The source was a closed capillary 10 mm long with a cross section of  $1 \times 1 \text{ mm}$ . The plasma in the capillary was heated by pulsed electric discharge with initial voltage, current density and duration selected in such a way that a uniform steady plasma column was produced as maximum temperature was reached. The temperature was determined from the absolute intensities of spectral lines. The measurements were made at wavelengths of 400-920 nm. The spectrum shows typical features of nonideality: disappearance of higher terms of the spectral series, and a reduction in the intensity of the photoionization continuum. These effects are interpreted on the basis of concepts of non-realization of bound states of atoms and ions under the effect of the plasma microfield. It is found that the region of unrealized states is 1.35-150 eV for atoms and 3.4-6.1 eV for ions under the given conditions. It is concluded that the classical theory is not applicable to description of the optical properties of a plasma in the region of electron concentrations exceeding  $5 \cdot 10^{18} \text{ cm}^{-3}$ . Figures 5, references 25: 23 Russian, 2 Western.

[57-6610]

**A SCIENTIFIC ENGINEERING APPROACH TO THE PROBLEM OF MODELING AND ANALYZING THE DYNAMICS OF THE PLASMOTRON AS A TECHNOLOGICAL FACILITY. II. METHOD OF DETERMINING THE STATIC CHARACTERISTICS OF THE PROCESS IN THE PLASMOTRON**

Novosibirsk IZVESTIYA SIBIRSKOGO OTDELENIYA AKADEMII NAUK SSSR: SERIYA TEKHNIЧЕСКИХ НАУК in Russian No 8(323), Issue 2, Jun 80 pp 69-73 manuscript received 3 Mar 80

BORISKIN, S. P., DEVYATOV, B. N. and LEVCHENKO, V. F., Novomoskovsk Affiliate of the State Scientific Research and Design Institute of the Nitrogen Industry and Products of Organic Synthesis

[Abstract] This is the second part of an article begun in IZV. SIB. OTD. AN SSSR: SER. TEKH. NAUK, No 3, Issue 1, 1980. An investigation is made of the transient process in a technological plasmotron with consideration of static characteristics of the process. Based on this analysis, several zones in a plasmotron with inter-electrode inserts are considered by using Damkoler numbers, which are the ratio of characteristic times: the time that a chemically reacting particle is in the plasmotron, and the time of the chemical reaction proper. The systems of equations in statics are solved by numerical methods with a reduction of each differential equation to an equation of first order. The given static characteristics are required for subsequent structural analysis of the dynamics of the plasmotron in accordance with the analytical expressions of functions of the transient process given in the first part of the article. References 15 Russian.

[63-6610]



ABSORPTION OF ULTRASOUND BY METALS DURING THEIR PLASTIC DEFORMATION

Moscow AKUSTICHESKIY ZHURNAL in Russian Vol 26, No 5, Sep-Oct pp 735-740  
manuscript received 28 Dec 78

KULEMIN, A. V., Central Scientific Research Institute of Ferrous Metallurgy  
imeni I. P. Bardin

[Abstract] A study was made of internal friction in polycrystalline metals, pure iron (0.003% C) with a b.c.c. crystal lattice and pure nickel (99.9% Ni), during plastic deformation by twisting. The ultrasonic method was used with longitudinal vibrations at 19.5 kHz, measurements were made by the thermoacoustic method at 20°C. The magnetoelastic effect was minimized by placing the specimens in a constant magnetic field of 280 Oe intensity. "Dumbbell" specimens of both metals were tested during the transient first stage of creep with strain rate decreasing and during the steady second stage of creep with strain rate remaining constant, also with the specimens in the annealed state before deformation. The results indicate a threshold amplitude of ultrasonic strain, above which the friction coefficient and strain rate increase rapidly. The results also indicate a profound effect of dislocation density and mobility on internal friction, confirming the theory that dislocation loops are generated during the first stage and then annihilated during the second stage of creep, also a strong effect of the relatively fast diffusion of carbon in iron but almost no effect of the much slower diffusion of impurities in nickel. Figures 4; references 10 Russian.

[35-2415]



#### TEMPERATURE-TIME DEPENDENCE OF THE RADIATION STRENGTH OF TRANSPARENT SOLIDS

Leningrad FIZIKA TVERDOGO TELA in Russian Vol 22, No 10, Oct 80 pp 3040-3046  
manuscript received 12 May 80

ZHURKOV, S. N., YERON'KO, S. B. and CIMEL', A., Physicotechnical Institute  
imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad

[Abstract] An analysis is made of the patterns of fracture of transparent solids by laser radiation from the standpoint of a kinetic mechanism of destruction as a cumulative process of dissociation of atomic bonds under the action of thermal fluctuations in a field of mechanical forces. Calculations are based on measurements made by the authors and taken from the literature. It is shown that the total time  $\tau$  of exposure is related to the electric field  $E$  of the incident radiation and temperature  $T$  by the expression  $\tau = \tau_0 \exp [(U_0 - \gamma_E E)/kT]$ , where  $U_0$ ,  $\gamma_E$  and  $\tau_0$  are material parameters. Experimental data show that there are limits to concepts of the "threshold" characteristics of the strength properties of optical materials. The interpretation of the atomic mechanism of destruction by light in terms of cumulative processes does not contradict the present notions of the part played by defects and inclusions, and should suggest ways of improving the strength properties of transparent solids. Figures 3, references 16:  
14 Russian, 2 Western.  
[30-6610]

#### OPTIMIZATION PROBLEM OF DYNAMIC INTERACTION OF A LAMINAR ORTHOGONAL PLATE WITH AN ACOUSTIC SHOCK WAVE

Yerevan UCHENYYE ZAPISKI YEREVANSKOGO GOSUDARSTVENNOGO UNIVERSITETA:  
YESTESTVENNYE NAUKI in Russian No 1, 1980 pp 31-35 manuscript received 7 Dec 79

AZATYAN, L. D., GNUNI, V. Ts. and SEYRANYAN, S. P., Institute of Mechanics,  
ArSSR Academy of Sciences

[Abstract] An analysis is made of the motion of an infinite elastic laminar plate under the action of a plane acoustic shock wave. The plate is assembled from cells of dimensions  $a \times b \times h$  lying on rigid hinged supports. It is assumed that the plate is made up of an odd number of layers that are formed by symmetric stacking of elementary layers of composite material, and that are symmetrically placed relative to the middle plane. The incident wavefront is taken as parallel to the surface of the plate. Thus the motion of the plate in each section between supports will be the same and will be symmetric relative to the middle of the section. Therefore the analysis is limited to examination of a single section. When the shock wave interacts with the plate, the external pressure is made up of the diffraction pressure acting on the stationary rigid plate, and the radiation pressure due to deformation of the plate. The

contact problem of hydroelasticity is reduced to a system of equations in which the first component of the overall pressure is given by the wave equation for the potential function of velocities disregarding equations of motion of the plates, while the radiation pressure is determined from simultaneous solution of the equation of motion of the plate and the wave equation. The first-approximation solution of the problem is used to analyze the optimization problem of determining the angles of strap bridging in layers of the plate and the distribution of thicknesses of the layers to minimize bending of a plate of given weight. The problem is reduced to a linear programming problem that can be solved by a method of successive unconditional minimization.

References 3: 2 Russian, 1 Western.

[61-6610]

## SUPERCONDUCTIVITY

UDC [621.313.322.81:537.312.62.]001.24

### CONTACTLESS SUPERCONDUCTING EXCITATION SYSTEMS FOR HIGH POWER TURBINE GENERATORS

Kiev PROBLEMY POVYSHENIYA NADEZHNOСТИ MOSHCHNYKH TURBOGENERATOROV in Russian  
1979 signed to press 26 Jul 79 pp 125-131

MARKOVSKIY, N. V. and SCHASTLIVYY, G. G., Kiev

[Abstract] The state of the art as reflected in the literature for magnetic flux pumps is reviewed. Since these pumps or topological generators make it possible to eliminate the contact rings, i. e. allow for excitation without breaking the superconducting circuit, such unipolar generators are not only promising for applications as excitation systems for high power turbine generators, they are feasible at the present time. A contactless superconducting exciter is proposed. It is placed in the hollow free end of the turbine generator shaft and is cooled by a controlled flow of cold gaseous helium. The exciter operates in two modes: with the fields removed and a control mode. In the first case, the three phase winding and the DC field winding are disconnected: the exciter buses are connected so as to be short circuited by all of the commutated elements, the legs of which are superconducting. The control mode is understood to be the feeding of the excitation winding, extracting energy from it when the generator is shut down and controlling the excitation current during the application and removal of its load. When the exciter functions with the superconducting winding in the control mode, it is necessary to be able to change the polarity of the exciter buses. When the fields are lifted, the superconducting circuit of the excitation winding is not broken, and the latter can operate indefinitely as a frozen field with the exciter disconnected. The basic dimensions and features of the proposed exciter working with a cryogenic turbine generator with the following parameters are estimated:  $0.8 \cdot 10^6$  ampere-turns and a magnetic flux of 3.5 Wb, values characteristic of an excitation winding for a generator with a capacity of 300 MVA. If the excitation winding is made of multicore ShNo-30/3 wire based on niobium stannide, containing  $25 \times 7,225$  superconducting filaments 5 micrometers in diameter, then with an excitation current of  $10^4$  amps and an exciter voltage of 10 volts, the time for complete filling the winding is 28 seconds. To provide for such voltage and current levels, the proposed exciter should have a bore diameter of 0.2 m, an active length of 0.2 m, 16 slots in the armature and two pairs of poles for the three phase winding, with three turns each in the armature winding coils. The working

temperature of the commutated elements is  $9^{\circ}$  K. The amplitude of the rotating magnetic field is 0.5 T, the bias magnetization field is 0.7 T; the main frequency of the three-phase winding is 50 Hz. Other specifications of the proposed generator are given and it is argued that the design will permit not only slow feeding of the superconducting winding, but also control of the cryogenic turbine generator voltage at the requisite rate. Figures 3; references 12: 6 Russian, 6 Western.  
[12-8225]

THE GINZBURG-LANDAU EQUATION FOR A TWO-COMPONENT FERMI LIQUID. 2. EQUATION FOR SUPERCONDUCTING PROTON CURRENT

Yerevan UCHENYYE ZAPISKI YEREVANSKOGO GOSUDARSTVENNOGO UNIVERSITETA:  
YESTESTVENNYE NAUKI in Russian No 1, 1980 pp 46-56 manuscript received 25 Jun 79

SEDRAKYAN, D. M. and SHAKHABASYAN, K. M., Department of General Physics,  
Department of Theoretical Physics, Yerevan State University

[Abstract] The method of propagators is used to derive an expression for superconductive proton current in the "pre"-phase of a neutron star, and an equation is found for the magnetic field inside the star. It is shown that accounting for rotation leads to proton vortex filaments in the vicinity of neutron vortex filaments. The magnetic field is  $10^8$ - $10^{10}$  T in the center of the vortex, and drops off abruptly at a distance of  $10^{-11}$  cm. Rotation also produces a weak homogeneous magnetic field. The authors thank Professor G. S. Saakyan and participants in a seminar at the theoretical physics department of Yerevan State University for discussions. References 12 Russian.  
[61-6610]

## A STUDY OF THE COOLING RATE OF THE COMPONENTS OF THE END REGIONS OF HIGH POWER TURBINE GENERATORS

Kiev PROBLEMY POVYSHENIYA NADEZHNOСТИ MOSHCENYKH TURBOGENERATOROV in Russian 1979 signed to press 26 Jul 79 pp 107-114

SCHASTLIVYY, G. G., FEDORENKO, G. M., KAPLUNOV, V. B., SMORODIN, V. I. and VYGOVSKIY, V. I., Kiev

[Abstract] In analyzing the reliability and load capacity of the end area components of a stator core for a high power turbine generator, special attention must be devoted to the end packets, because of heating during variable load conditions and the concomitant heat liberation. An analysis of the basic parameters characterizing the cooling rate of the end packets of the stator core of generators with capacities of 200 MW (packet thickness of 0.047 m) and 500 MW (packet thickness of 0.02 m) shows that for a hydrogen pressure of 0.3 to 0.4 MPa, the time constant for the heating of the teeth of these packets can be reduced down to 120 to 150 seconds, a figure which provides for a normalized value of the heat transfer coefficient of 500 to 600 W/m<sup>2</sup>·°C. Criteria governing optimization of heat transfer are discussed and tests of the temperature, heat transfer and gas velocities were performed in a short circuit mode on a 500 MW generator, with the measurements made in the regions of the end packets of the clamping glange and pins. The experimental data show that the heat transfer rate in this region is quite nonuniform. Simple analytical expressions are given for the coefficients of cooling rate increase which are recommended for the calculation of the heat transfer in channels between the pins, the clamping flange and end packet of turbine generators with a radial cooling system. Figures 1; references 7 Russian. [12-8225]

# A STUDY OF THE HEATING OF A TGV-300 GENERATOR IN INDUCTION OPERATION WITHOUT EXCITATION

Kiev PROBLEMY POVYSHENIYA NADEZHNOСТИ MOSHCINYKH TURBOGENERATOROV in Russian 1979 signed to press 26 Jul 79 pp 84-92

YEZOVIT, G. P., KHLIBINSKIY, I. V., ASANBAYEV, V. N., SARATOV, V. A., Kiev and PODOL'SKIY, V. V., All-Union Scientific Research Institute of Electrical Power Engineering, Moscow

[Abstract] Special tests were performed at a number of state regional electric power stations (GRES) to ascertain the permissibility of operating TGV-300 generators as induction machines with a loss of excitation and to determine the heating of the major components in this case. Changes were made in the cooling system of the stator core; three different designs of the iron laminations of the end packets of the stator were tested to find the optimal cooling configuration: additional slits were cut along the axis of the teeth and the slots. The tests of these modified generators were performed in three ways with an active load of 120 MW in operation as induction machines: 1. A long term mode to determine the amount and nature of the heating of the active parts of the generator (the internal power requirements of the set were met in this case by a standby transformer); 2. A short-term mode to determine the behavior of the set in induction operation with the internal power needs covered by the working transformer; 3. A short-term mode with partial losses of excitation to determine the ultimate point of stable generator operation for the case of reactive power consumption. Trials were run with loads of 180, 240 and 300 MW with rapid load drop to 120 MW and subsequent manual resynchronization. The test procedures and instrumentation are described in detail. It is found that with induction operation, the greatest heating of the end packets of the stator core occurs in the region of the crown of the tooth where there are no slits. Approximate calculations are made for the losses in the generator rotor for induction operation at the Tripol'skaya GRES with a load of 140 MW. Analysis of the TGV-300 test results with the improved design of the end packets of the stator core shows: 1. Cutting additional slits substantially reduces the heating of the end packets in the area of the base of the slot and tooth base at the end face of the stator core in induction operation without excitation; 2. Cutting additional slits likewise reduces the heating of the region of the crown of the teeth of the end packets, thereby improving the load range of the generator in the above operating modes. To reduce this heating of the crown region of the teeth near the packets following after the end packets of the stator core, it is recommended that slits be cut in the teeth of these packets to a depth of no more than the height of the tooth. Figures 3; references 5 Russian.

[12-8225]



# OPTIMIZING THE THERMAL STATUS OF THE COMPONENTS OF THE END ZONE OF LARGE TURBINE GENERATORS OPERATING IN FLEXIBLE LOAD MODES

Kiev PROBLEMY POVYSHENIYA NADEZHNOСТИ MOSHCINYKH TURBOGENERATOROV in Russian 1979 signed to press 26 Jul 79 pp 57-70

SCHASTLIVY, G. G., FEDORENKO, G. M., BUT, A. A., KRAMARSKIY, V. A., SPIVAK, B. V. and GLIDER Ye. M., Kiev

[Abstract] Experimental studies of a number of generators have shown that damage to the end sections are observed in 75% of the machines and cause breakdowns in some cases. The temperature fields found for the end packet of the stator core on the turbine side and data for the heating of large turbine generator stators in the case of fluctuating loads show that the difference between the average temperatures from the stator tooth to the back of the stator in the core varies from 4.5 to 9.9°, while for the end packet, it fluctuates from 10.1 to 25.6°. Such nonuniformity in the radial temperature gradients attests to the unequal distribution of thermomechanical stresses over the depth and radius of the packets in various operating modes. One of the causes of damage to the end packets is the thermal expansion displacement of the stator winding relative to the teeth of the end packet. The hypothesis proposed for the buckling of these packets is: because of the different coefficients of linear expansion and heating of the copper of the windings and the iron of the stator, the copper shifts relative to the end packets. When the winding is secured tightly in the slot, a displacement of the winding rod can lead to the shifting of the wedges, bending of the iron teeth and buckling of the end packets. This paper derives analytical expressions for the maximum relative expansion and displacement of the core of the copper winding of the stator at the outside of the end packet. Values found experimentally for a TGV-200 turbine generator of the Dolmel company exhibit good agreement with the theoretical relative displacement of the end packet windings; this agreement is illustrated graphically showing the change in the length as a function of time for various ways of controlling coolant flow during load relief and shutdown. While measures to step up the cooling of the entire machine improve the operational conditions, they still do not eliminate the potentially damaging temperature gradients; thus a promising approach is the local intensification of the cooling as a function of the space-time distribution of the losses and the stabilization and regulation of the temperature of individual structural components in various operating modes. A system to do this, proposed by the Institute of Electrodynamics of the Ukrainian SSR Academy of Sciences and the Scientific Research Institute of the Elektrot'yazhmash Plant, is described; control of the thermal status of the components is achieved through the application of a complex control computer which assesses a large number of operating parameters. It is noted that additional research is required to work out the optimum control algorithms. References 6: 4 Russian; 2 Western.

[12-8225]



# STOCHASTIC CONDITIONS OF THERMOCHEMICAL HETEROGENEOUS PROCESSES THAT TAKE PLACE IN A FIELD OF LASER RADIATION

Moscow PIS'MA V ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian  
Vol 32, No 10, 20 Nov 80 pp 608-611 manuscript received 2 Oct 80

BOBYREV, V. A., BUNKIN, F. V., KIRICHENKO, N. A., LUK'YANCHUK, B. S. and  
SIMAKIN, A. V., Physics Institute imeni P. N. Lebedev, USSR Academy of Sciences

[Abstract] Thermodynamic processes initiated by laser radiation have been intensively studied in recent years. The results of research on laser combustion of metals has shown that the process of development of thermochemical instability terminates with the system leaving the steady state or with the onset of self-oscillations. Similar effects are observed in a number of other nonequilibrium systems in which chemical reactions take place. In this paper the authors report experimental observation of a new type of quasi-steady state in heterogeneous reactions--laser stochastic combustion. In the theory of nonlinear oscillations this kind of motion of a dynamic system on the phase plane corresponds to the so-called "strange attractor." The experiments were done on the dynamics of heating of titanium targets by cw laser emission from a CO<sub>2</sub> laser with power of 18 W. The targets were cylindrical with thickness varying over a range of 0.5-1.5 mm, diameter 2-5 mm and mass of 30-100 mg. Temperature of the target was measured by a chromelalumel thermocouple welded to the reverse side of the target. The time dependence and time derivative of the temperature were measured by an oscilloscope. It is shown that stochastic combustion arises with sharp focusing of radiation on the surface of the target and is due to the development of new degrees of freedom in the nonlinear system due to the spatial inhomogeneity of the problem. Figures 2, references 9 Russian.

[39-6610]

UDC 621.316.5:537.529

# INVESTIGATION OF THE COMMUTATION PROPERTIES OF ELECTRICALLY EXPLODED FOILS IN ARC-QUENCHING MEDIA. I

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 50, No 11, Nov 80  
pp 2283-2294 manuscript received 18 Dec 79

ANDREZEN, A. B., BURTSEV, V. A., VODOVOZOV, V. M. and DROZDOV, A. A.

[Abstract] The authors study the behavior of electrically exploded aluminum foil 6, 10 and 20  $\mu$ m thick in artificial quartz dust. Emphasis is given to the energy characteristics of the explosion. The results of the experiments show that conditions for quasi-steady boiling of aluminum are attained at the maximum discharge current. However, the explosion proper, accompanied by loss of metallic

conductivity, takes place following the unsteady stage of existence of the liquid metal in the superheated state with introduced specific energy and relative resistance depending on maximum current density. Approximate formulas are derived for the relative resistance of the foil gap as a function of the specific insertion energy for preceding stages and for stages of the explosion proper. The preceding stages, including the stage of the superheated liquid, are described by linear functions  $R/R_0 = f(w)$ , while the stage of the explosion proper is described by an exponential function with exponent depending on maximum current density. The resultant facts show the importance of the rate of energy input to the conductor, which is determined chiefly by current density, and also by unsteady processes on the stage of existence of the superheated liquid and loss of metallic conductivity. Figures 6, references 13: 14 Russian, 1 Western.

[48-6610]

LIMITS OF SOLUTIONS AND COMPLEXITY OF SYSTEMS OF CONVEX DIOPHANTINE INEQUALITIES

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 255, No 2, 1980 pp 296-300  
manuscript received 25 Jun 80

TARASOV, S. P. and KHACHIYAN, L. G., Computing Center, USSR Academy of Sciences, Moscow

[Abstract] The authors consider a system of  $m$  convex polynomial inequalities  $f_i(x_1, x_2, \dots, x_n) \leq 0$ ,  $i = 1, 2, \dots, m$ , where

$f_i(x) = f_i(x_1, x_2, \dots, x_n) \in Z[x_1, x_2, \dots, x_n]$  are polynomials that are convex in  $R^n$  with integer coefficients. The degree  $d$  of the system is the maximum of the degrees  $d_i$  of the polynomials in the system, and the height  $h$  of the system is the maximum of the absolute values of the integer coefficients of polynomials  $f_i(x)$ . The following theorems are proved: 1. Let  $N$  be an arbitrary periodic set in  $R^n$ . If the system of convex polynomial inequalities of degree and height no greater than  $d$  and  $h$  is consistent in  $N$  (i. e. has a solution  $x \in N$ ), then its solution set in  $N$  contains a solution from the Euclidean ball  $\|x\| \leq R$ , where  $\log R = \frac{1}{2} D[d^3 n]^{d/2} \log h d n$ ,  $d \geq 2$ ; 2. At fixed  $d \geq 1$ , the problem of determining consistency of systems of convex diophantine inequalities of degree no greater than  $d$  belongs to the class of NP problems that are solvable in a time that is polynomial with respect to input on a non-deterministic Turing machine; 3. There exists a deterministic Turing machine that determines consistency, solves systems of convex diophantine inequalities and prints out the answer in the binary system of notation in a time  $T$  that satisfies the estimate

$\log \frac{T}{m} \leq d^{3d/2} n^{d/2+1} \log h d n + \text{const}$ , where  $n$ ,  $m$ ,  $h$ ,  $d$  are the number of unknowns, the number of inequalities, the height and the degree of the system respectively. References 11: 6 Russian, 5 Western.  
[26-6610]

## GROUP PURSUIT OF SEVERAL EVADERS BY A SINGLE PURSUER

Leningrad VESTNIK LENINGRADSKOGO UNIVERSITETA: MATEMATIKA, MEKHANIKA, ASTRONOMIYA in Russian No 13, Issue 3, Jul 80 pp 50-57 manuscript received 15 Feb 80

PETROSYAN, L. A. and SHIRYAYEV, V. D.

[Abstract] The authors consider a differential game in a plane with three players: a pursuer P and evaders  $E_1, E_2$  moving at constant speed with capability of changing direction at any instant. Evader  $E_1$  is caught if the positions of P and  $E_1$  coincide at some instant. The pursuer has information at each instant on his own position, on the positions of the other players and on the direction of their velocities. Each of the evaders has information on his own position, that of the other evader, and the position of the pursuer. At each instant the players can choose the direction of their own motion or the direction of the velocity vector (the magnitude of the velocity is constant and equal to  $u$  for P and  $v_1$  for  $E_1$ ). The velocities of the players are arbitrary, the only constraint being that  $u > \max\{v_1, v_2\}$ . The direction of the velocity of P is uniquely defined by the vector  $\vec{\phi} = (\phi_1, \phi_2)$ , where  $(\phi_1)^2 + (\phi_2)^2 = u^2$ . Similarly the direction of the velocity of  $E_1$  is uniquely defined by the vector  $\vec{\psi}_1 = (\psi_1^1, \psi_2^1)$ , where  $(\psi_1^1)^2 + (\psi_2^1)^2 = v_1^2$ . Permissible strategies of the players are defined in an earlier paper [see L. A. Petrosyan, "Pursuit Games with a Lifeline with Many Participants," Izvestiya Akademii nauk ArmSSR, Vol 2, No 5, 1966, pp 333-340]. The solution is found on the assumption of programmed definition of the pursuit procedure. Optimum controls are found that realize a saddle point of the advantage function in the antagonistic case, and a Nash equilibrium situation in the nonantagonistic case. The optimum strategy of the pursuer consists in applying the rule of parallel pursuit ( $\Pi$ -strategy) in sequence to each of the evading players. Figures 3, references 6 Russian.

[21-6610]

## SIMPLE PURSUIT AND EVASION ON A COMPACT

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 254, No 6, 1980 pp 1318-1321  
manuscript received 3 Jun 80

IVANOV, R. P., Bulgaria

[Abstract] The author considers a game in which several players pursue a single evader on a bounded set in  $n$ -space, the motions of the players being described by simple controllable systems of differential equations. It is assumed that all players have identical dynamic capabilities, so that the sole advantage of the pursuers is in their numbers. It is shown that if there are at least  $n$  pursuers, the game can be concluded in a finite time. Otherwise the evader can avoid encounters with the pursuers for an infinite time. References 7 Russian. [37-6610]

UDC 517.92

## AN EFFICIENT METHOD OF SOLVING DIFFERENTIAL GAMES WITH MANY PURSUERS

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 256, No 3, 1981 pp 530-535  
manuscript received 11 Aug 80

PSHENICHNYY, B. N., CHIKRIY, A. A. and RAPPOPORT, I. S., Institute of Cybernetics, UkSSR Academy of Sciences, Kiev

[Abstract] Effectively verifiable sufficient conditions of completion within a finite time from predetermined initial positions are established for quasi-linear differential games in which the terminal set is the sum of a finite number of convex sets. The results given in this paper are new even for the case of a single pursuer. In some special cases the time of completion of the game and the strategy of the pursuers can be evaluated and calculated in explicit form. The results are illustrated by examples. References 9 Russian. [50-6610]

CSO: 1862

- END -

**END OF**

**FICHE**

**DATE FILMED**

22 April 1981